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REGENERATIVE ENGINE ANALYSIS PROGRAM

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APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

The results of previous regenerative engine technology programs have become somewhat obsolete by intervening technology development. In 1980, the Army supported several engine design investigations to update regenerative cycle engine data for helicopter application. Results of this effort will be utilized in conjunction with parallel efforts at other engine companies and in-house to formalize future efforts directly related to small fuel efficient gas turbine engines.

Mr. Albert E. Easterling of the Propulsion Technical Area, Aeronautical Technical Division served as project engineer for this effort.

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A parametric cycle analysis and a preliminary recuperator design study were conducted for a 500-hp intermediate rated power (IRP) recuperative helicopter engine. The U-tube recuperator with airflow inside the tubes and single cross flow gas path was found to be the lightest design in the .6 - .8 effectiveness range considered for the cycle analysis. An optimum cycle is recommended as a compromise between minimum mission fuel consumption and minimum engine + mission fuel weight:

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60% IRP (300 hp): Temperature $T_{4.0}$ = 2520°R (inlet gas producer turbine nozzle)

Pressure Ratio PR = 7.4

Recuperator Effectiveness E = .76

100% IRP (500 hp): $T_{4.0}$ = 2750°R, PR = 10.8, E = .75

A preliminary mechanical design was completed for a free power turbine engine using the recommended cycle.

With presently available 500 hp engine technology, the recuperative cycle offers 18% fuel savings over the nonregenerative cycle. For a typical 2-hour helicopter mission the engine + mission fuel weight is 3.7% higher than for a nonregenerative engine. The fuel savings compensate for the higher engine acquisition cost if fuel cost is assumed to escalate to approximately $1.80/gal. (1979 dollars).

On the basis of the results of this preliminary study, it is recommended to proceed with the demonstration of a recuperative helicopter engine of the 500-hp class.

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INTRODUCTION

The escalation of fuel cost and the uncertainty of future fuel availability have reaffirmed the requirement for more efficient gas turbine engines. In the present state of the art, significant component performance improvements are difficult to achieve. Therefore, it appears worthwhile to consider heat recuperation as an alternate means of reducing the fuel consumption of the conventional gas turbine cycle.

The objectives of this study are to identify promising regenerative gas turbine cycles and heat exchanger concepts and to conduct a preliminary design analysis of a fuel-efficient regenerative turboshaft engine of the 500 hp class suitable for helicopter propulsion, including engine performance definition, installation characteristics, and estimated acquisition cost.

The primary design objective is to achieve minimum specific fuel consumption (SFC) at cruise power (40-60% of intermediate rated power (IRP)). In addition, two main mechanical design conditions are imposed: (a) a free power turbine with front power extraction at constant 20,000 rpm over the entire flight power range and (b) modular construction with an integral inlet particle separator and an integral lubrication system. For this preliminary design study, component technology levels consistent with those currently available for a 500 hp demonstrator engine and design conditions consistent with MIL-E-8593 A are assumed.

The analysis was conducted in two phases:

Phase I - Parametric engine cycle and heat exchanger design analyses
- Task 1: Preliminary and refined parametric cycle analyses
- Task 2: Heat exchanger analysis

Phase II - Regenerative engine configuration definition and preliminary design.

The parametric cycle analysis was conducted in sufficient detail to provide SFC variations over the entire engine operating range for standard sea level conditions. The heat exchanger analysis addressed multitube and multiwave plate recuperators and provided the preliminary design data, i.e., air/gas flow path configuration, core surface geometry and density, and core weight used in the parametric cycle analysis. The cycles were compared on the basis of the fuel consumed in a typical helicopter mission, and the most promising cycle and heat exchanger design were selected as a compromise between minimum fuel consumption and minimum engine + mission fuel weight. A preliminary engine life cycle cost assessment involving total mission life fuel cost and

engine development, acquisition, and maintenance cost was carried out to ensure that the fuel economy achievable with the selected cycle was not offset by increases of the other cost items.

The preliminary design effort of Phase II addressed a 500-hp class engine with a single spool gas producer, a free power turbine, and a cylindrical recuperator wrapped around the engine exit diffuser. The compressor was a scaled-down design of an existing nonregenerative 800-hp engine. A complete flow path of the turbine-diffuser section with single-stage gas producer and power turbines was defined and an engine cross section and an installation drawing were produced.

PRELIMINARY PARAMETRIC CYCLE ANALYSIS

REGENERATIVE CYCLE CHARACTERISTICS

The performance characteristics and trends of the open regenerative gas turbine cycle are well known. For each turbine inlet temperature and recuperator effectiveness, there is an optimum cycle pressure ratio that depends mainly upon the polytropic efficiency index of the turbomachinery. The performance trends are illustrated in Table 1, which lists optimum cycle pressure ratio, specific fuel consumption, and specific power for 0.5, 0.65, 0.75 and 0.85 recuperator effectiveness, 2400, 2600 and 2800°R turbine inlet temperature and turbomachinery polytropic efficiency indices of 0.84 and 0.86. A sum of 13% stagnation pressure loss in the burner, the heat exchanger, and the components connecting ducts is assumed.

For constant temperature and polytropic index, the optimum cycle pressure ratio decreases with increasing effectiveness, while it increases with increasing temperature and polytropic index. SFC decreases with increasing temperature, effectiveness, and polytropic index. Specific power increases with temperature and polytropic efficiency index, but decreases slightly with increasing effectiveness as a result of decreasing optimum pressure ratio.

With regard to mechanical design, one of the main performance characteristics is the moderate cycle pressure ratio, which does not exceed 10 except for low effectiveness and high cycle temperature values. Another important characteristic is the effect of temperature increase on SFC and specific power. In the 2400-2600°R range, a 100° temperature rise decreases SFC by 1.5-2% and increases specific power by roughly 10%. In the 2600-2800°R range, the corresponding SFC gain is reduced to 1%, while specific power still increases by roughly 7%. Since low engine weight and compactness is a premium, there is a strong incentive to increase the cycle temperature beyond the point of diminishing SFC return. In the small power class, however, increasing manufacturing difficulties and cost and performance penalties associated with small turbomachinery components oppose the trend toward maximizing specific power.

From Table 1 a specific fuel consumption of the order of 0.4 lb/hp/hr could be anticipated for a cycle temperature of 2600-2800°R, a polytropic efficiency index of .84 (parameters that are characteristic of today's advanced technology in small gas turbines), and a recuperator effectiveness of 0.7.

TABLE 1. POTENTIAL PERFORMANCES OF REGENERATIVE CYCLES

Heat Exchanger Effectiveness	0.50		0.65		0.75		0.85	
Polytropic Efficiency Index	0.84	0.86	0.84	0.86	0.84	0.86	0.84	0.86
$T_{4.0} = 2400^{\circ}R$								
PR_{opt}	10.0	11.0	8.0	8.6	6.8	7.4	5.4	5.9
SFC (lb/hp-hr)	0.458	0.423	0.430	0.397	0.404	0.377	0.372	0.348
Specific Power (hp/lb/sec)	132	145	130	141	128	139	120	136
$T_{4.0} = 2600^{\circ}R$								
PR_{opt}	11.9	13.0	9.3	10.0	7.9	8.4	6.5	7.0
SFC	0.434	0.403	0.412	0.381	0.387	0.362	0.357	0.339
Specific Power	157	171	153	169	151	166	145	162
$T_{4.0} = 2800^{\circ}R$								
PR_{opt}	13-15	15-17	10.8	11.6	9.0	10.0	7.6	7.8
SFC	0.421	0.385	0.400	0.372	0.377	0.355	0.353	0.330
Specific Power	178	195	176	192	174	190	170	183

The selection of a regenerative cycle and its optimization for helicopter application essentially depends upon the type and duration of the mission. Since one of the main requirements of the study is to achieve minimum SFC at cruise part-power, a typical mission with a substantial cruise leg is assumed for the parametric cycle analysis.

APPROACH

Parametric Cycle Definition

The main regenerative cycle parameters are:

- Pressure Ratio PR
- Temperature $T_{4.0}$ (Turbine stator inlet)
- Recuperator Effectiveness E

With a minimum of three discrete values for each parameter, a matrix of 27 cycles would be generated. However, the minimum number of parametric cycles can be reduced to 9 by associating each pair of temperature and recuperator effectiveness with the corresponding optimum pressure ratio. The cycles are then compared on the basis of maximum performance potential, which is of primary interest for the study.

A matrix of twelve cycles with three temperatures, $T_{4.0}$= 2200, 2400, and 2600°R, and four recuperator effectivenesses, E =.5, .65, .75, and .85, has been selected for preliminary analysis. Those conditions have been tentatively assumed for the 60% IRP points. The matrix is shown on Figure 1 with the optimum cycles labeled A-L.

The optimum pressure ratio exceeds 9 for cycles I', K', L' with low recuperator effectiveness and high temperature values. Assuming those conditions for the design points at 60% of IRP, cycle pressure ratios in excess of 15 would result for the IRP points of cycles K' and L', which would be difficult to achieve efficiently in the 500 hp engine size. On the other hand, a substantial departure from the optimum pressure ratio entails only minor SFC penalties for cycles with low recuperator effectiveness and high turbine inlet temperature. The maximum pressure ratio for the part-power design points thus has been tentatively limited to 8.5.

In order to achieve minimum part-power SFC in a regenerative engine, it is necessary to maintain a high part-power cycle temperature. Conversely, once optimum part-power conditions have been selected, the problem is to maintain the temperature constant or to minimize its increase at maximum power. This can be achieved by gradually opening the turbine passage areas from part to full power. For air-cooled stator and rotor bladings, the resulting mechanical difficulties are prohibitive, and variable geometry currently is used only in the stator blading of the

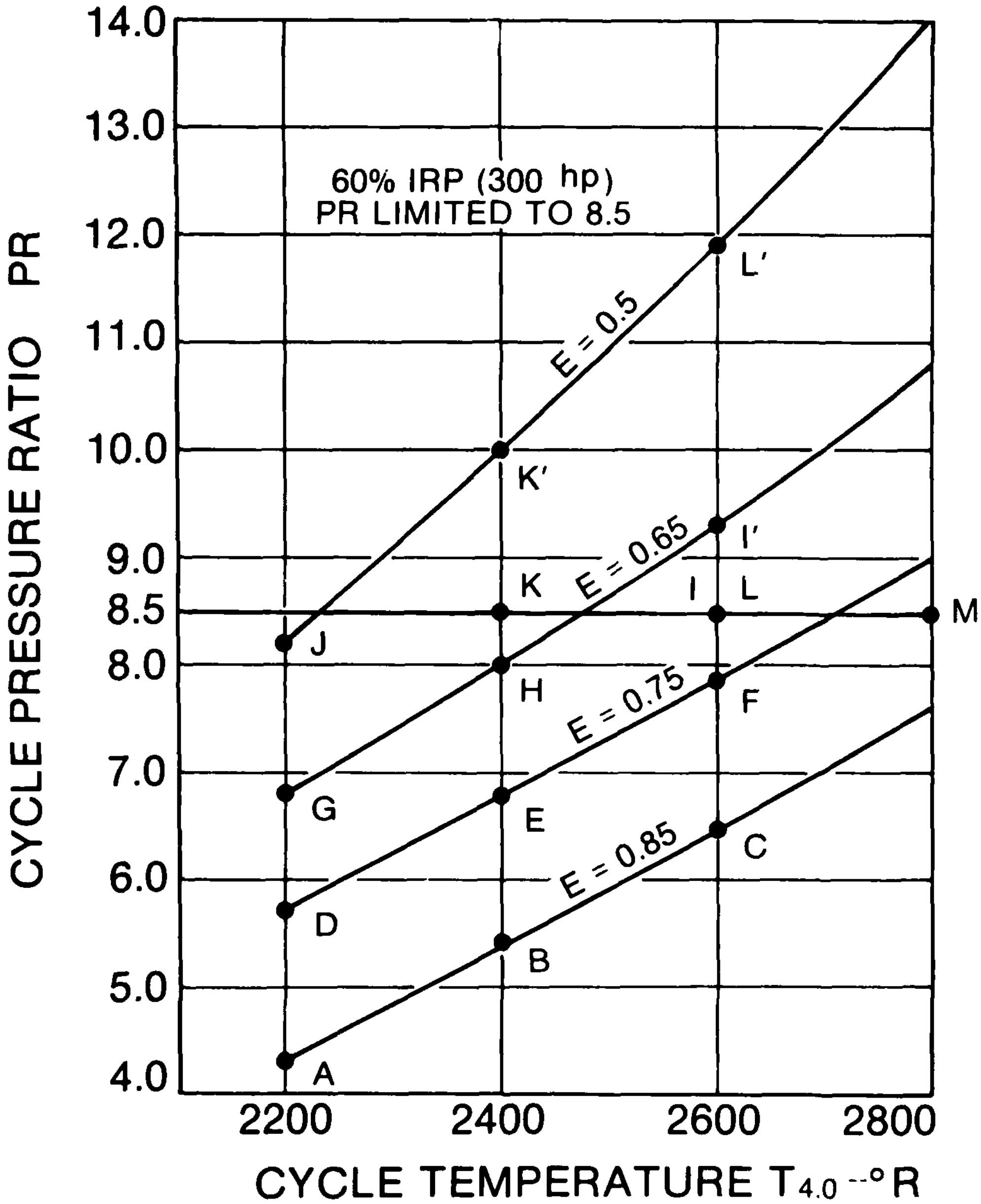


Figure 1. Optimum regenerative cycles and preliminary cycle matrix A-L

power turbine. For the present study, both fixed and variable power turbine stator geometries are considered.

The main difficulty associated with variable turbine geometry lies in the compressor, whose operating line approaches the surge line at part power faster than in a conventional, constant turbine geometry engine. To evaluate and compare the cycle performances over the entire engine power range for constant and variable power turbine geometry, it is therefore necessary to evaluate the operating conditions of the compressor. For that purpose a basic performance map derived from the test results of the 2A + 1C compressor of an existing, nonregenerative 800 hp engine has been selected as representative of the study engines (Figure 2). For each cycle, the map is scaled in pressure ratio and mass flow rate to achieve the required 60% IRP design conditions. Generally, scaling up in pressure ratio tends to result in an overoptimistic surge line prediction. It is therefore desirable for the basic map to permit the highest 60% IRP cycle pressure ratio to be achieved without or with minimum upscaling. The selected map fulfills that condition, since the maximum 8.5 PR can be obtained with an efficiency close to the maximum value.

For each preliminary cycle, constant gas producer turbine efficiency and constant recuperator effectiveness are assumed over the entire operating range. The compressor operating line then is located on the scaled map as a first approximation. This determines cycle mass flows, pressures, and temperatures over the entire engine power range; these are used for preliminary recuperator design analysis.

The pressure ratio and the mass flow scaling factor (i.e., the location of the 60% IRP point in the basic map), are varied until favorable compressor operating conditions are obtained on the scaled map from engine idle (50 hp) to IRP (500 hp). This is done with the aid of a general gas turbine performance analysis code. The program first establishes the 60% IRP performance in the design mode, checks the results in the off-design mode, and then computes the off-design performances with the power turbine geometry specified for each case.

Component Efficiencies, Cooling Air, and Loss Assumptions

For the 60% IRP (300 hp) point, the following assumptions have been made:

- Compressor polytropic efficiency: $\eta_{p_c} = .84$
- Gas producer turbine adiabatic efficiency: $\eta_{ad_{GPT}} = .86$

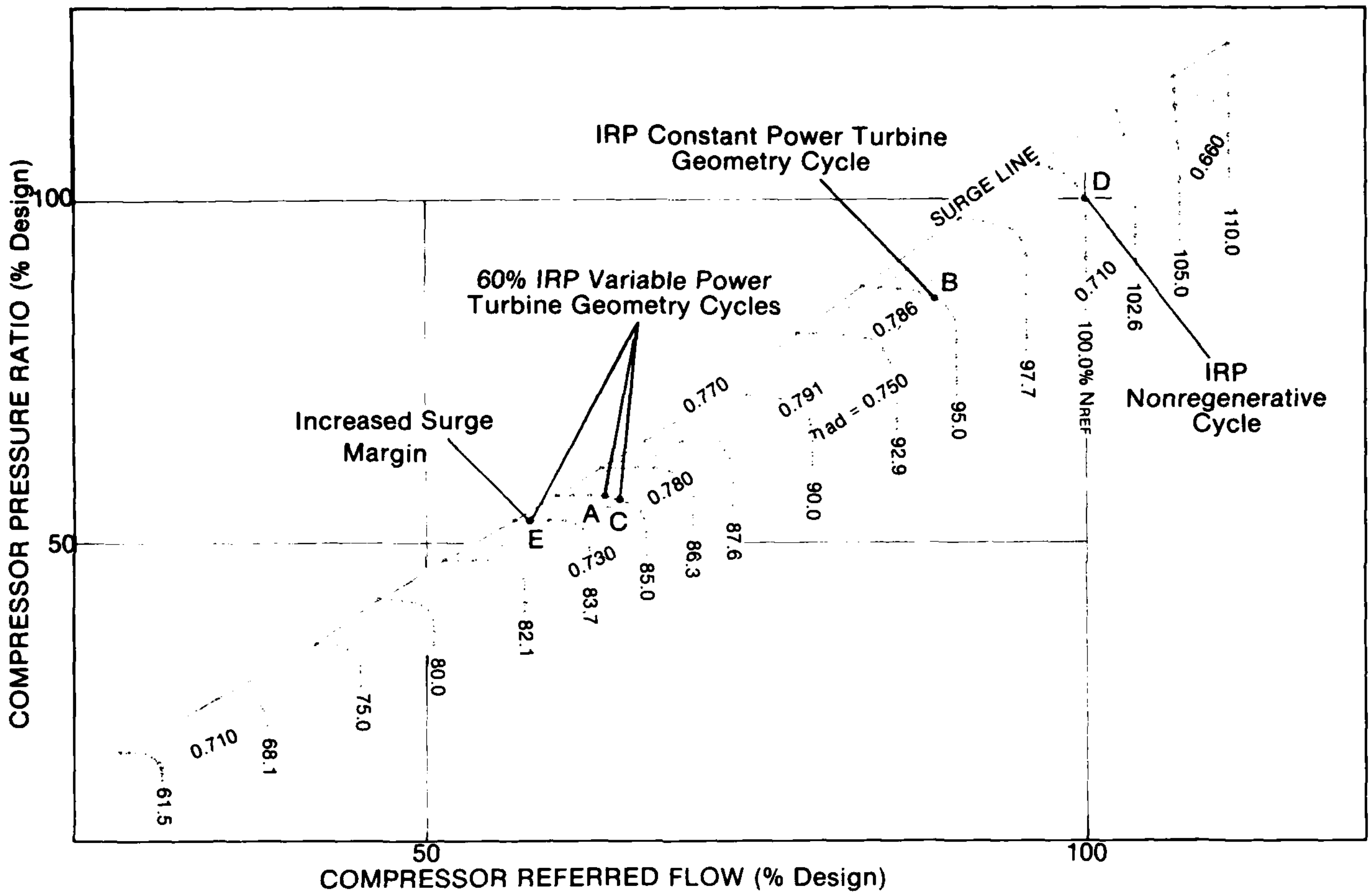


Figure 2. Basic compressor map with representative points selected for parametric cycle analysis.

Total pressure losses:

o	Recuperator	$\Delta P/P$ = 2% for the air side 2.5% for the gas side
o	Ducts connecting the recuperator to the compressor, the burner, and the exhaust	1% each
o	Power turbine exit diffuser	2%
o	Burner	3.5%
o	Burner efficiency η_B = 99%	
o	Mechanical losses	.5% of the gas producer and power turbine shaft power

The following total cooling air flow rates are assumed:

For IRP $T_{4.0} = 2800^{\circ}R$:	11.0%
$2600^{\circ}R$:	5.5%
$2400^{\circ}R$:	1.9%

Those air quantities are based on preliminary heat transfer calculations, assuming maximum metal temperatures of $1900^{\circ}F$ for the C101 nozzle and 1760, 1700 and $1640^{\circ}F$ for the tip, mean and hub section, respectively, of the C103 rotor bladings. Cooling air is extracted at exit of the compressor and bypasses the recuperator. The distribution between the gas producer turbine stator and rotor is shown on Figure 3.

Power turbine efficiency is assumed as follows:

For constant geometry:	$\eta\ ad_{PT}$ = .88 = const.
For variable geometry:	$\eta\ ad_{PT}$ = .88 (open stator setting) .84 (closed stator setting)

A linear variation with power is assumed between the open and the closed positions.

Leakage of compressed air: 1%

The parametric analysis is carried out for uninstalled conditions. Specifically, the pressure losses of the inlet duct and particle separator, and the power of the customer generator, customer hydraulic pump and particle separator scavenge blower are not included in the performance calculations.

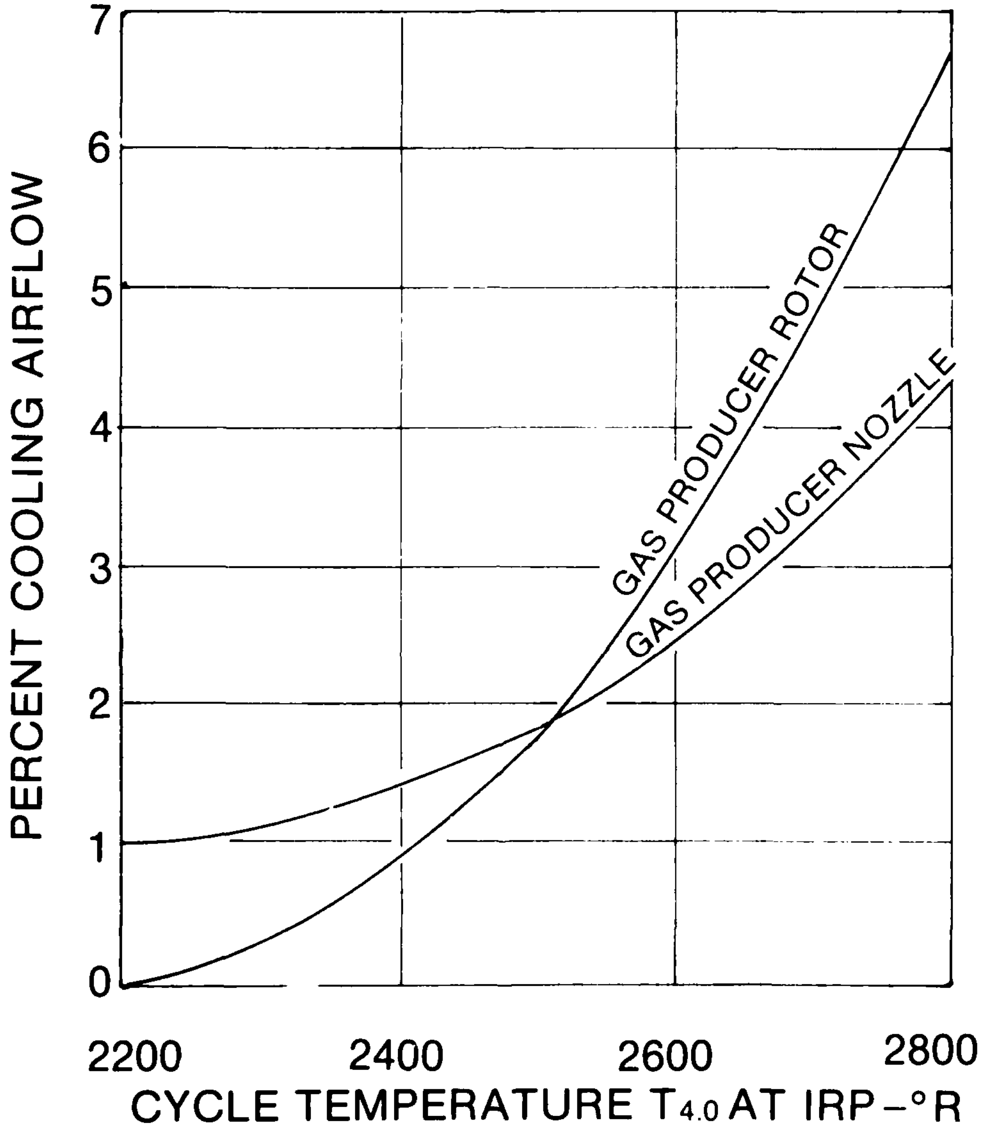
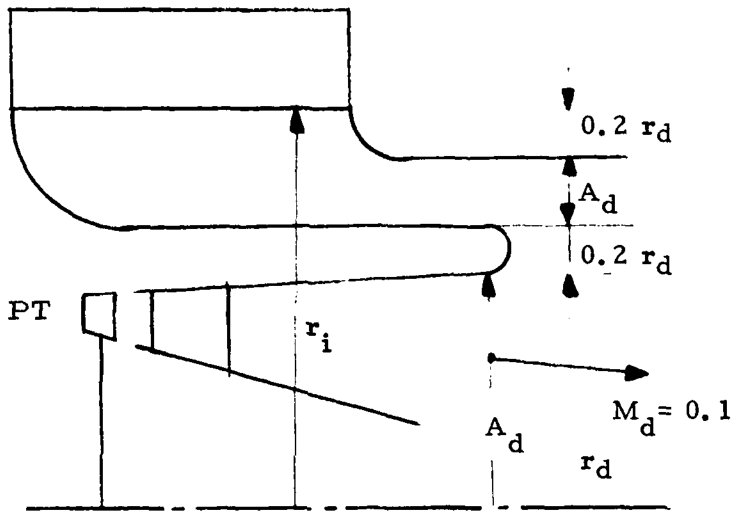


Figure 3. Turbine cooling air schedule

Recuperator Configuration

For all parametric cycles, the recuperators are assumed to be designed with a cylindrical core and wrapped around axial flow diffusers with an exit Mach number of .1 at the 60% IRP point. The recuperator core inner radius is determined as follows:



The diffuser exit area A_d and radius r_d are determined from the mass flow, the power turbine exit conditions, and the diffuser exit Mach number $M_d = .1$, assuming a 2% total diffuser pressure loss. Provision then is made for a 20% r_d increase of the channel radius to turn the flow 180 degrees back into an axial flow annular duct of equivalent area A_d. A 20% r_d increase of the outer duct radius is provided for the 90 degree turn into the radial direction of the recuperator gas flow.

Recuperator and Cycle Selection Criteria

Two heat exchanger types - a multitube and a multiwave plate recuperator - are evaluated. The multiwave plate type uses the cross-counterflow path shown on Figure 4, a configuration that has been developed for a vehicular gas turbine. For the multitube recuperator, the two cross-counterflow configurations sketched on Figure 5 are analyzed. For a given parametric cycle point, i.e., for given recuperator effectiveness and SFC performance, the recuperator with the lowest weight results in the best mission performance. This selection is made for the entire

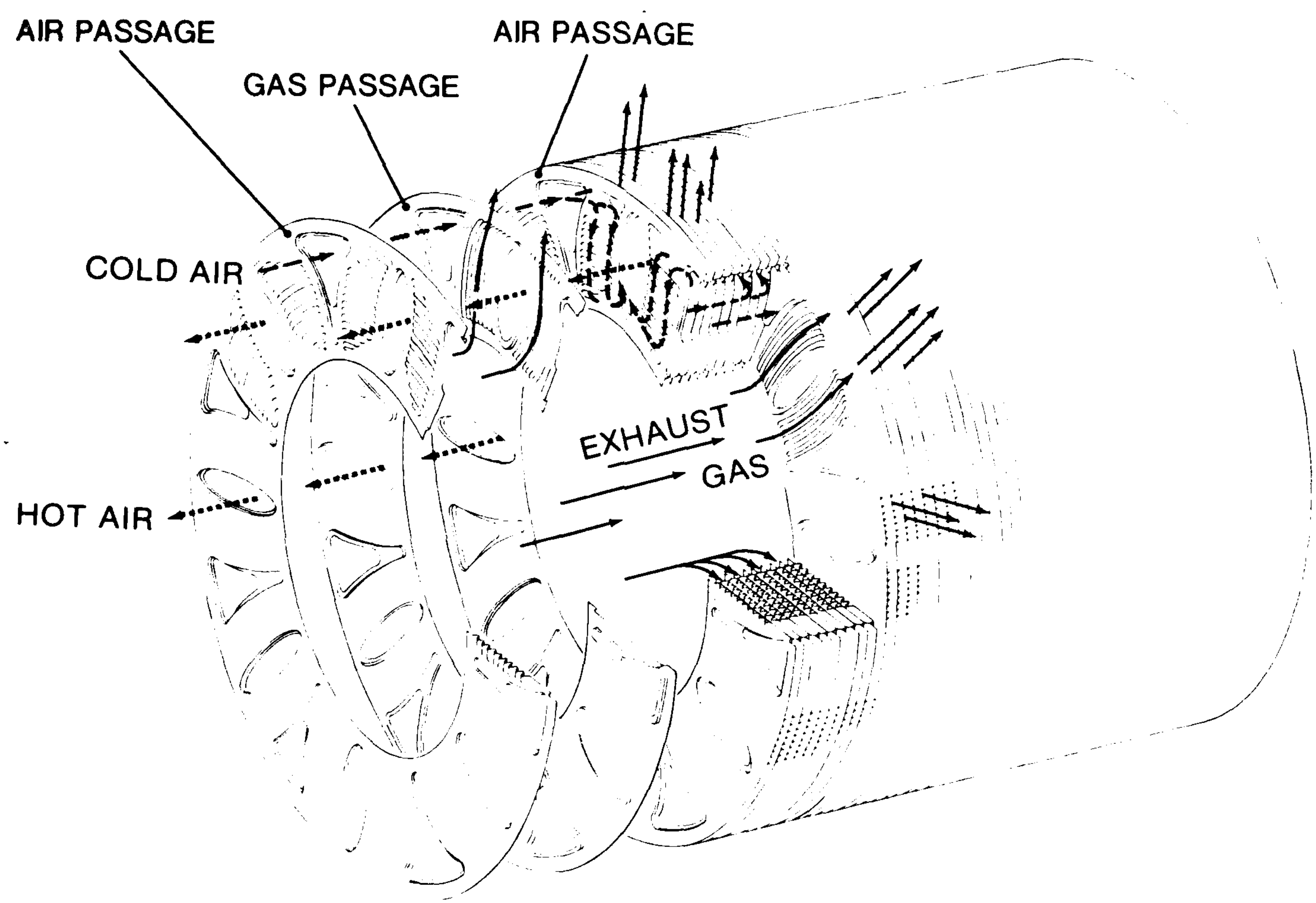


Figure 4. Cross-counterflow multiwave recuperator core

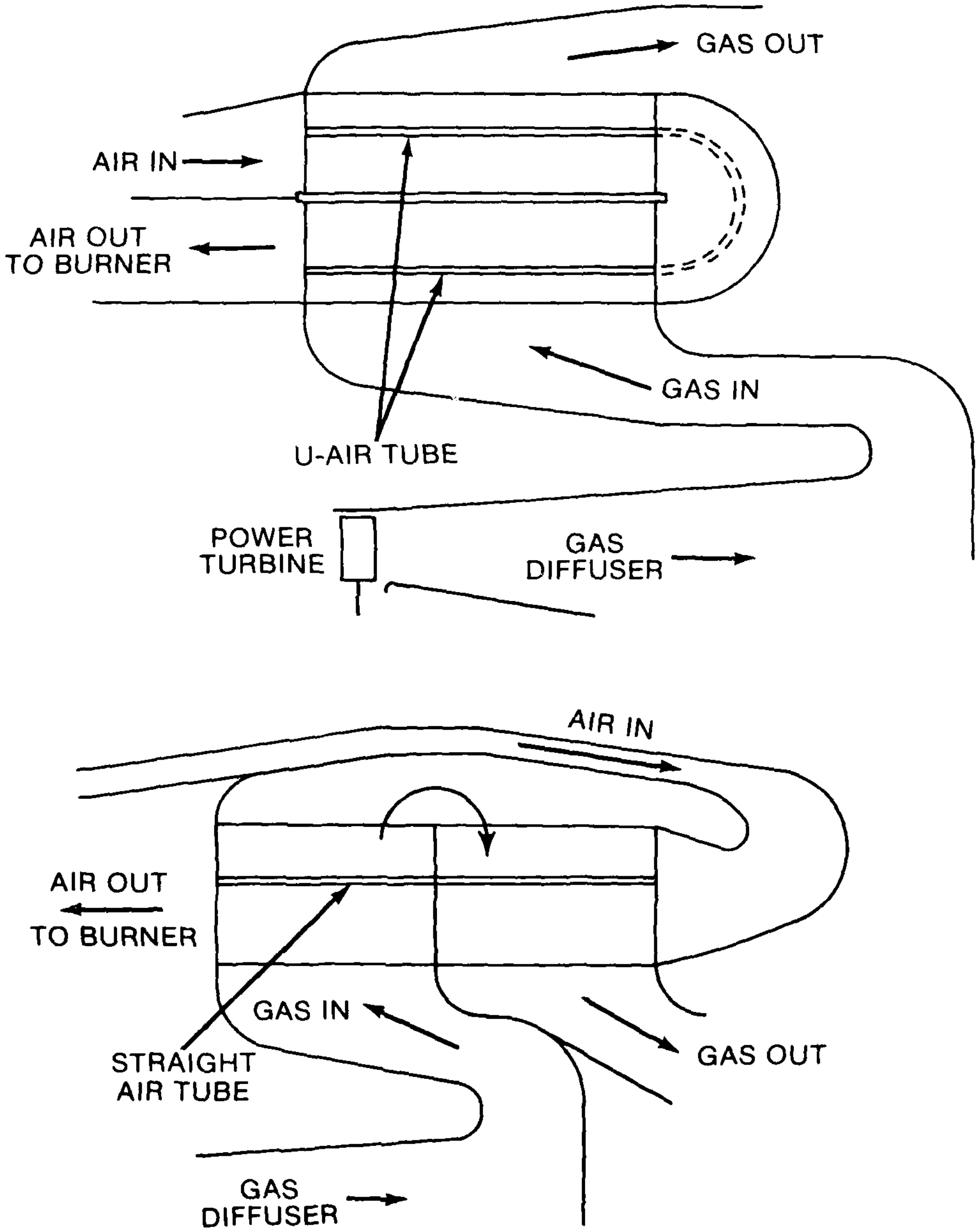


Figure 5. Crossflow multitube recuperators

parametric cycle analysis. The most promising cycle is selected as a compromise between minimum mission fuel consumption and minimum engine + mission fuel weight. A preliminary engine life-cycle cost assessment involving mission life fuel cost and engine development, acquisition, and maintenance cost is carried out to ensure that the fuel economy achievable with the selected cycle is not offset by prohibitive engine cost items.

Helicopter Mission Profile

A mission profile is needed to compare the performance merits of the parametric cycles. The typical helicopter mission shown in Table 2 has been assumed for that purpose. This mission profile is not used for a helicopter mission analysis, but simply for the evaluation of the order of magnitude of the mission fuel quantity as a preliminary cycle comparison basis.

TABLE 2. TYPICAL HELICOPTER MISSION

Cycle Point	Mode	Time (min.)	Air-speed (kn)	Power (% IRP)	Actual Power (hp)	Fuel Consump-tion Factor
a)	Ground Idle	18		10	50	0.15
b)	Takeoff	6		100	500	0.05
c)	Climb/Hover	24		75	375	0.20
d)	Cruise	54	62	55	275	0.45*
e)	Descent	18		40	200	0.15

Total Mission Time 2 hours

*Average Cruise Conditions

Engine Weights

Engine weights are estimated on the basis of the weight of a representative, nonregeneration 800-hp engine, W_o, which includes an inlet particle separator, an integral lubrication system, accessories, and an alternator.

The weights W_{e-r} of the basic parametric engines without recuperator are assumed to be directly proportional to the air mass flow rates at the IRP (500 hp) points, which yields the following formula:

$$W_{e-r} = W_o \cdot Wa/W_{a_o} = 43.4\ W_a \qquad (1)$$

(The "square-cube" law, which is often used for gas turbine weight evaluations, is not applicable when scaling down a small engine, since for most of the components at least one dimension, such as blading chord length or sheet metal thickness, cannot be reduced because of manufacturing requirements or other related restrictions.)

The recuperator core weight is calculated from the heat transfer analysis and design data. The recuperator wrap-up hardware consists of an envelope-collector made of 0.04-inch sheet metal with 0.08-inch-thick flanges, the core header and rear support plates, and two baffle plates, all of 0.04-inch thickness.

Constant vs Variable Cycle Temperature Effect on Compressor Operating Conditions

A number of preliminary computations were carried out to achieve favorable compressor operating conditions while maximizing the engine power range at constant temperature. Figure 6 shows the operating line obtained with the following 60% IRP conditions:

$T_{4.0} = 2600^{o}R$, $E = .65$, $PR = 8.5$ (Cycle I)

using the basic map of Figure 2. Constant cycle temperature was achieved over the range of 275-420 hp with a 7.5% surge margin at the 275 hp point.

The most significant characteristic is the progressively larger mass flow increments needed to achieve a given power increment toward the higher power levels. This is due to the cumulative effects of increasing recuperator pressure losses and decreasing compressor efficiency along the operating line. In this case, the total pressure losses of the recuperator and the connecting ducts increase from 8.5% at 300 hp to 14% at 420 hp, and the adiabatic compressor efficiency decreases from .788 to .744. As a result, the power turbine pressure ratio, which increases from 2.64 at 275 hp to 2.80 at 375 hp, decreases to 2.49 at 420 hp, and the IRP point (500 hp) can only be obtained with an increase of the cycle temperature.

With the matching freedom afforded by variable power turbine geometry, different IRP conditions can be obtained with different passage areas of the power turbine stator, i.e., different evolutions of the cycle temperature over the engine power range. Especially, gradually increasing $T_{4.0}$ from $2600^{o}R$ at 275 hp to $2772^{o}R$ at 500 hp yields the operating line shown on Figure 7 with a more favorable compressor match. The

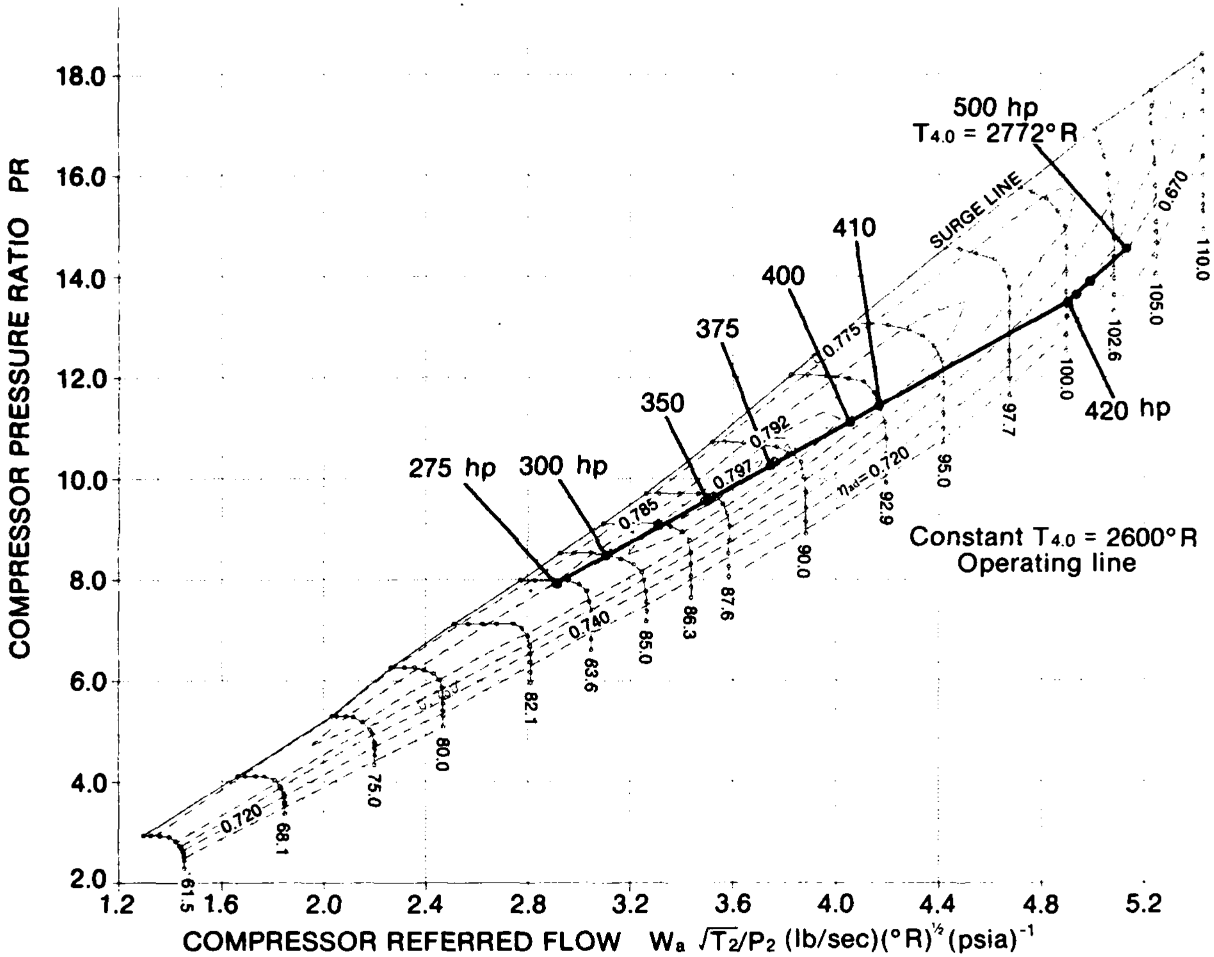


Figure 6. Compressor operating line with maximum power range at constant cycle temperature $T_{4.0}$=2600°R

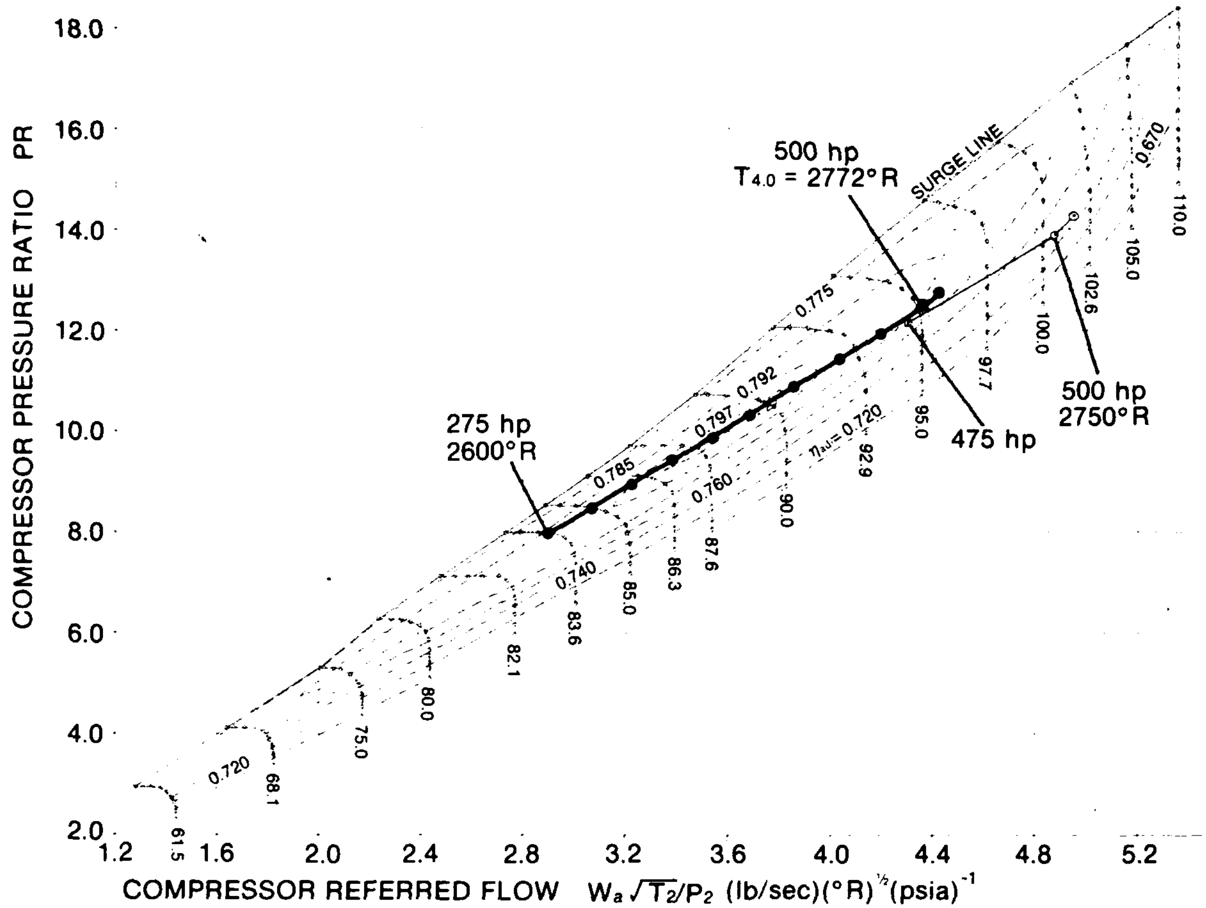


Figure 7. Operating lines with cycle temperature $T_{4.0}$ gradually increasing from 2600°R at 275 hp to 2772°R and 2750°R at 500 hp

referred mass flow rate of the power turbine at the 500 hp point has decreased from 3.35 to 2.64 lb/sec, indicating a 21.5% decrease of the stator opening needed to achieve the IRP point. This results in a smaller turbine section, and the smaller variation of stator geometry also minimizes the resulting aerodynamic efficiency penalty.

Constant vs Variable Power Turbine Geometry

The performance of engines with constant and variable power turbine geometry can be compared on the basis of the two extreme cases of equivalent cycle temperature at the 60% IRP design and at the IRP points. In the first case, a large increase of cycle temperature is needed to achieve the IRP point. Conversely, in the second case, part-power conditions are obtained with a large decrease of the cycle temperature, i.e., with a substantial SFC penalty.

Figure 8 shows the operating line obtained for Cycle F ($T_{4.0}$=2600°R, E = 0.75, PR = 7.9, variable PT geometry). Figure 9 shows the operating line optimized for the constant geometry case with equivalent $T_{4.0}$=2770°R at the IRP point. The cycle temperature at the 60% IRP point drops to 2387°R, yielding an SFC of .467 that compares with .432 for the cycle with variable power turbine geometry. Figure 10 compares the SFC's over the entire power range. Table 3 lists the SFC's for the various power ratings of the mission assumed in Table 2.

TABLE 3. SFC COMPARISON OF ENGINES WITH VARIABLE AND CONSTANT POWER TURBINE GEOMETRY

Power (hp)	50	200	275	375	500	
SFC (lb/hp-hr) Constant PT Geometry	0.858	0.529	0.479	0.441	0.413	Cycle FC
SFC Variable PT Geometry	0.761	0.476	0.437	0.417	0.413	Cycle F
Δ SFC	-0.097	-0.053	-0.042	-0.024	0	

Since the mission legs are flown at low altitudes, the actual SFC's are essentially equivalent to those at sea level static conditions (for the highest average altitude of 3000 ft. of the cruise leg, the SFC is only 2% smaller than the SLS value). From Table 3, the mission fuel savings for

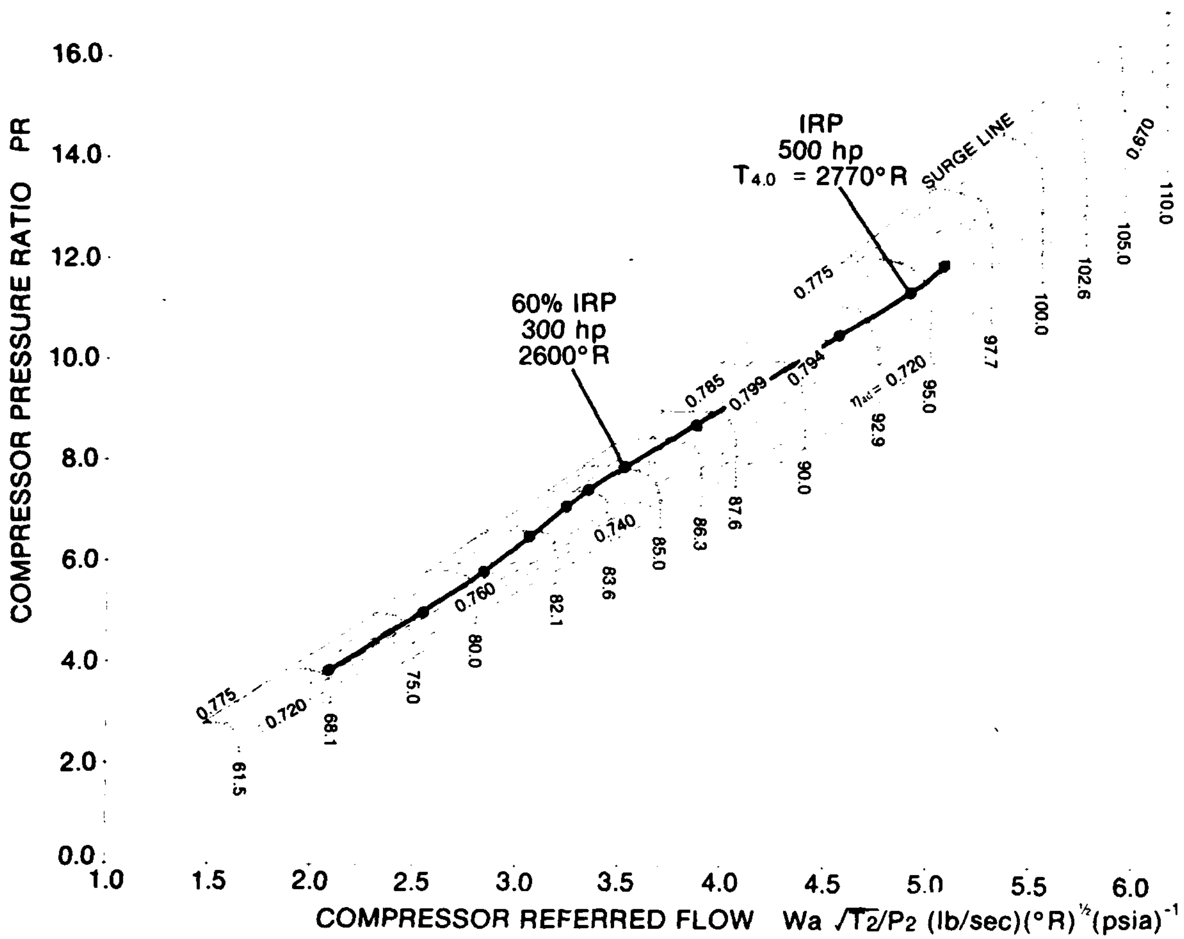


Figure 8. Operating line for cycle F with variable power turbine geometry

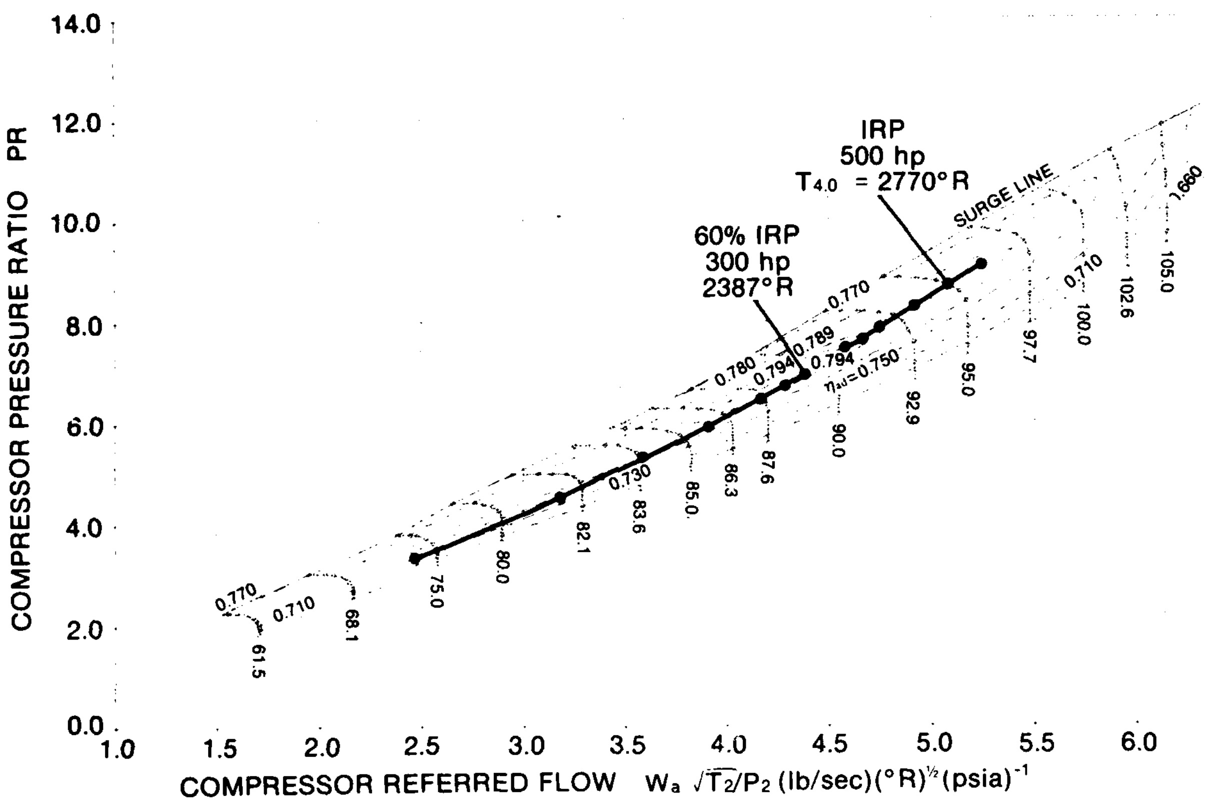


Figure 9. Operating line for constant power turbine geometry and $T_{4.0}$ = 2770°R at 500 hp

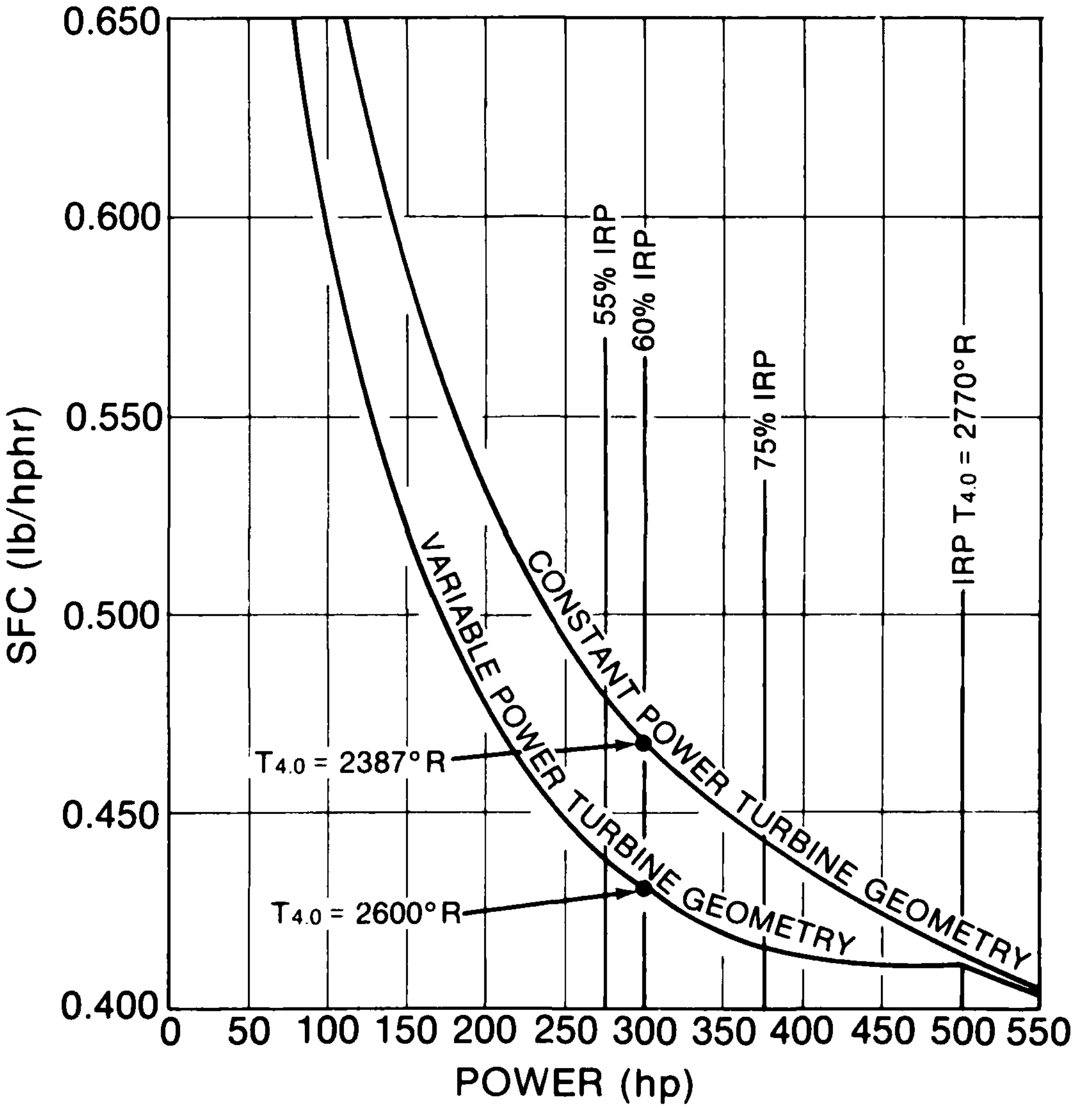


Figure 10. SFC comparison of cycles with constant and variable power turbine geometry

the variable geometry engine consequently is:

$$\Delta W_f = \underset{\text{Idle}}{0.097 \cdot 50 \cdot 0.3} + \underset{\text{Descent}}{0.053 \cdot 200 \cdot 0.3} + \underset{\text{Cruise}}{0.042 \cdot 275 \cdot 0.9}$$

$$+ \underset{\text{Climb / Hover}}{0.024 \cdot 375 \cdot 0.4} = 18.6 \text{ lb per mission}$$

This fuel weight savings is higher than the additional weight of the variable power turbine geometry. Moreover, the mission life fuel savings is substantial even for a minimum engine mission life of 5000 hours:

$$W_{f_{tot}} = 18.6 \cdot 5000/2 = 46{,}500 \text{ lb per engine.}$$

Assuming a conservative fuel price of $1 per gallon, the mission life fuel cost savings is $7000, which substantially exceeds the additional cost of the variable power turbine geometry.

For the parametric study, variable power turbine geometry is assumed for all cycles and constant geometry is reconsidered for the recommended cycle only.

Recuperator Design Analysis

Preliminary heat transfer analysis and design optimization have been conducted for the waveplate and tubular recuperators shown on Figures 4 and 5 using the cycle data of point M of Figure 1, which was initially considered as a candidate with constant temperature between 60% and 100% IRP.

For the waveplate type, the three core configurations shown on Figure 11 have been analyzed. For the tubular type the staggered arrangements shown on Figure 12 have been analyzed, using the dimpled and finned tube configurations shown on Figure 13.

Pressure losses and heat transfer data used in the analysis are based on in-house test results for the friction factors f and the Colburn j-factors of the waveplate recuperator. For the tubular recuperator, in-house test results for the inner air side and published data for the gas side flow and heat transfer conditions are used.

RESULTS OF THE PRELIMINARY CYCLE AND RECUPERATOR ANALYSIS

Cycle Analysis

The compressor operating lines have been defined for the 12 selected parametric cycles. All use the same representative point A (85% of

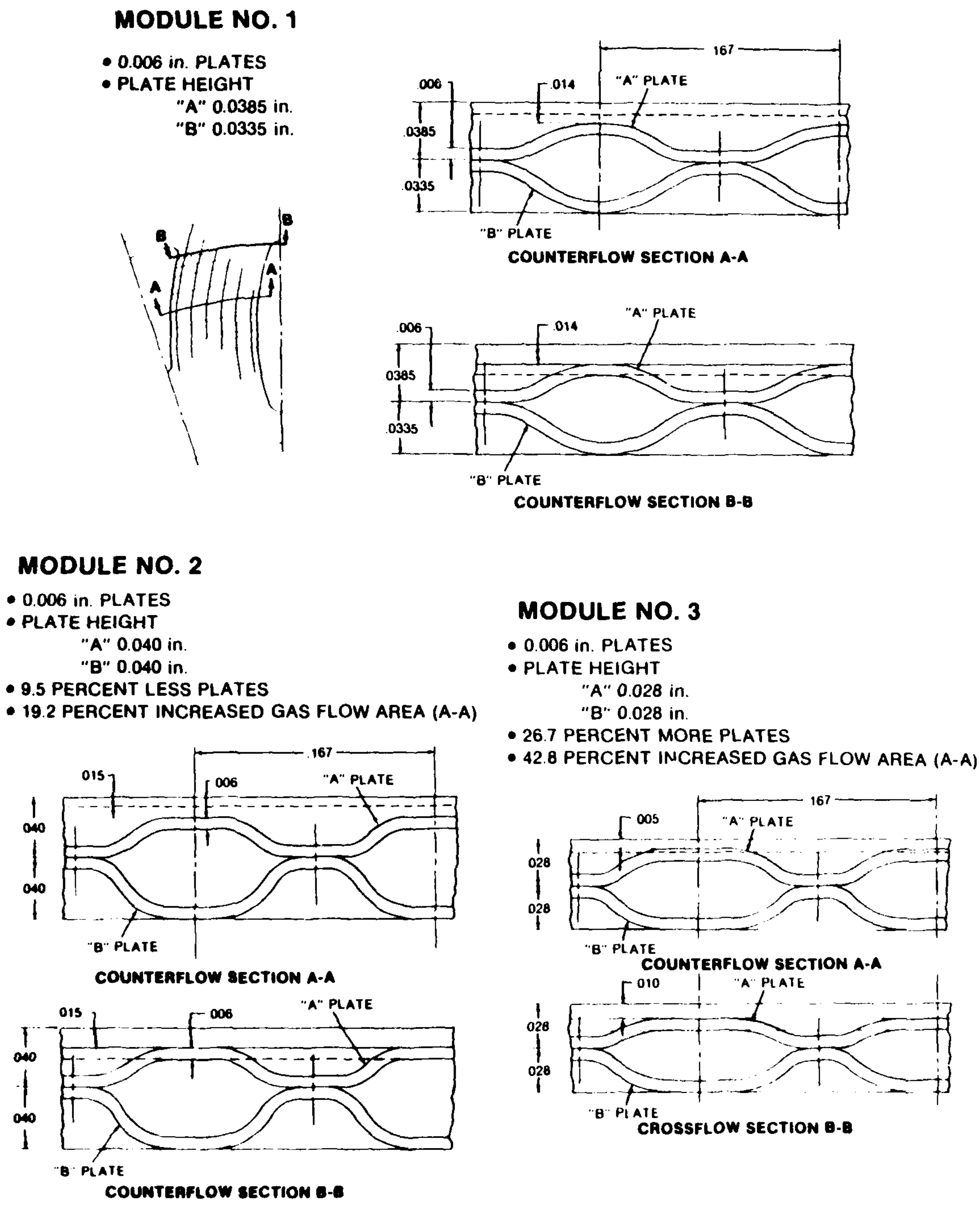
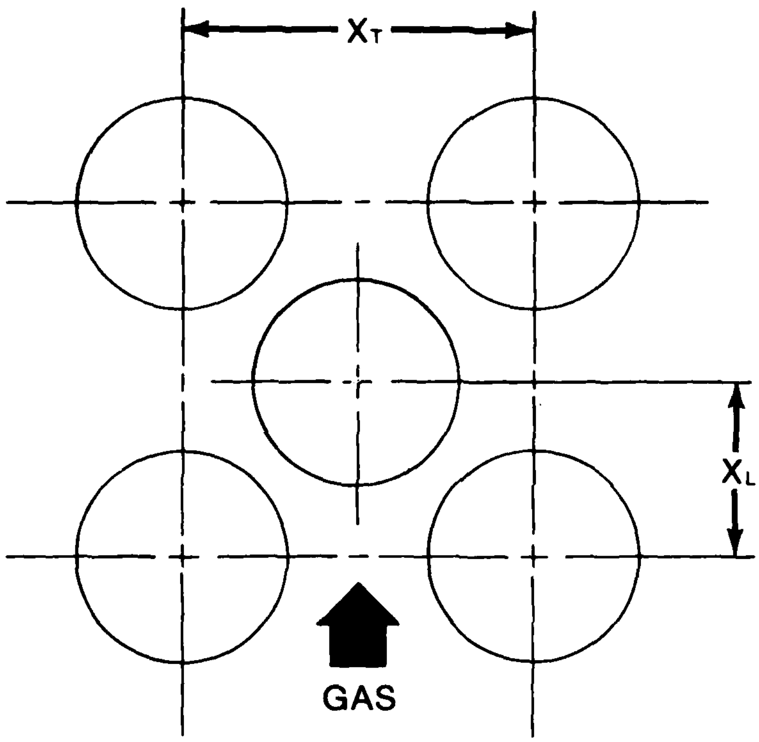


Figure 11. Waveplate recuperator core modules



DIMPLED TUBES

$X_T = 1.5\ D_O$ $X_L = 1.0\ D_O$

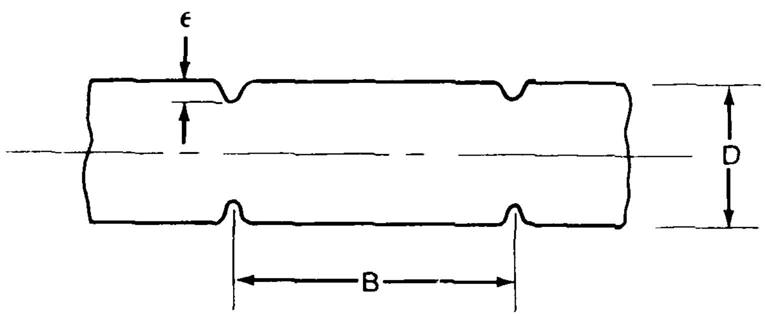
$X_T = 1.25\ D_O$ $X_L = 1.0\ D_O$

FINNED TUBES

$D_{FIN}/D_O = 1.25$ $X_T = 2.0\ D_O$ $X_L = 1.0\ D_O$

$D_{FIN}/D_O = 2.0$ $X_T = 3.0\ D_O$ $X_L = 1.5\ D_O$

Figure 12. Staggered tube arrangements



B Dimple Pitch = 0.1875 in.

D Tube Diameters = .10, .15, .20, .25 in.

ϵ/D Dimple Height/Diameter = .0588, .105, .155

Diameter of Tube = .10, .15, .20, .25 in.
(D_{TUBE})

Diameter Fin/Tube = 1.25, 2.0
(D_{FIN}/D_{TUBE})

Number of Fins = 30/in.

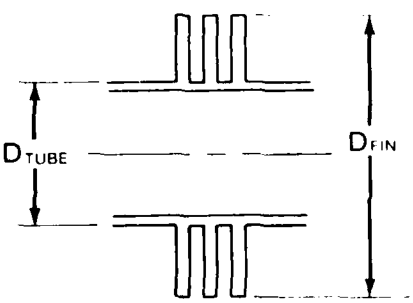


Figure 13. Dimpled and finned tube geometries

referred speed for the 60% IRP points) of the basic map. The IRP cycle temperatures $T_{4.0}$ have been selected so that the corresponding compressor operating points lie around 95% of referred design speed, i.e., near the limit past which compressor efficiency rapidly decreases on the operating line. This ensures power turbine expansion pressure ratios that continuously increase with increasing power and also provides for adequate altitude performance margin. For all cycles, $T_{4.0}$ is assumed to increase linearly from 275 hp (55% IRP) to 500 hp (IRP). Figure 8 shows the operating line for Cycle F, which is typical of the compressor operating conditions obtained in the preliminary cycle analysis.

Figure 14 shows plots of SFC at 60% IRP vs cycle temperature. The curves exhibit minimum SFC's in the range $T_{4.0} = 2400\text{-}2500^{\circ}R$. The main reason for the SFC increase beyond that temperature level is the detrimental effect of the turbine cooling air bypassing the heat exchanger. Figure 15 shows the fuel quantity consumed for the helicopter mission assumed in Table 2. The trend is similar to that shown on Figure 14, indicating that cycle temperatures below $2300^{\circ}R$ at 60% IRP are not competitive for the moderate recuperator effectiveness levels likely to be used (.6-.8) in helicopter applications.

For the refined parametric study, the cycle matrix will be selected following the calculation of engine + mission fuel weight.

Recuperator Analysis

Recuperator core heat transfer analysis and design optimization have been conducted for the following 60% IRP cycle conditions:

$$T_{4.0} = 2800^{\circ}R, \quad PR = 8.5 \text{ (Cycle M of Figure 1)}$$

and with the corresponding inner core diameter of 15.3 inches determined according to the assumptions of Recuperator Configuration.

The calculated performance characteristics determine the weight of a core with 15.3 inch inner diameter for the effectiveness range of .6-.85 and total pressure losses ranging from 2-8%.

a) Waveplate Design

Figures 16 and 17 show the design performance of the best waveplate configuration analyzed in the study. It will be seen that the effectiveness achievable with the total core pressure loss $\Sigma \Delta P/P =$ 4.5% assumed in the parametric analysis is .832 with an outer core diameter of 27 inches. The corresponding core length L is 5.4 inches and the core weight 83 pounds. This is not necessarily the minimum core weight, since effectiveness and total core pressure loss can be traded off for equivalent cycle performance. This

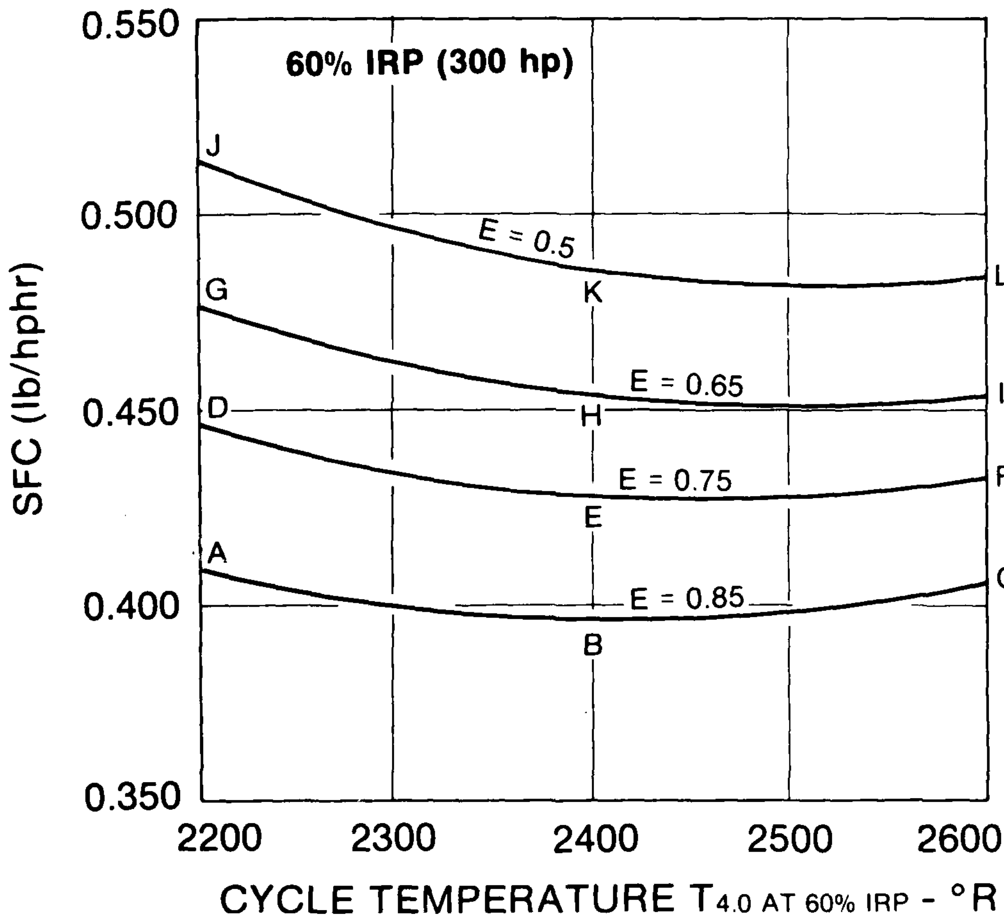


Figure 14. SFC comparison of cycles A-L at 300 hp (60% IRP)

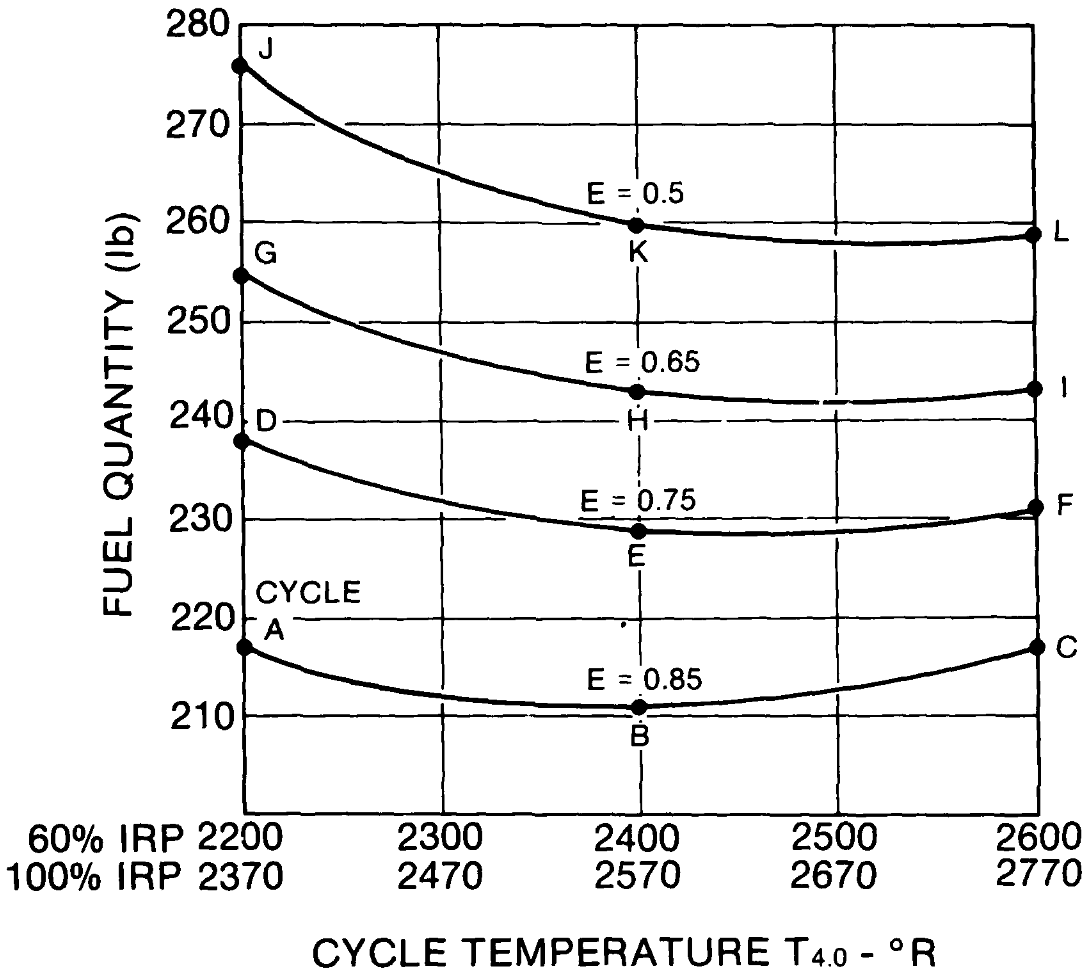


Figure 15. Mission fuel consumption, Cycles A-L

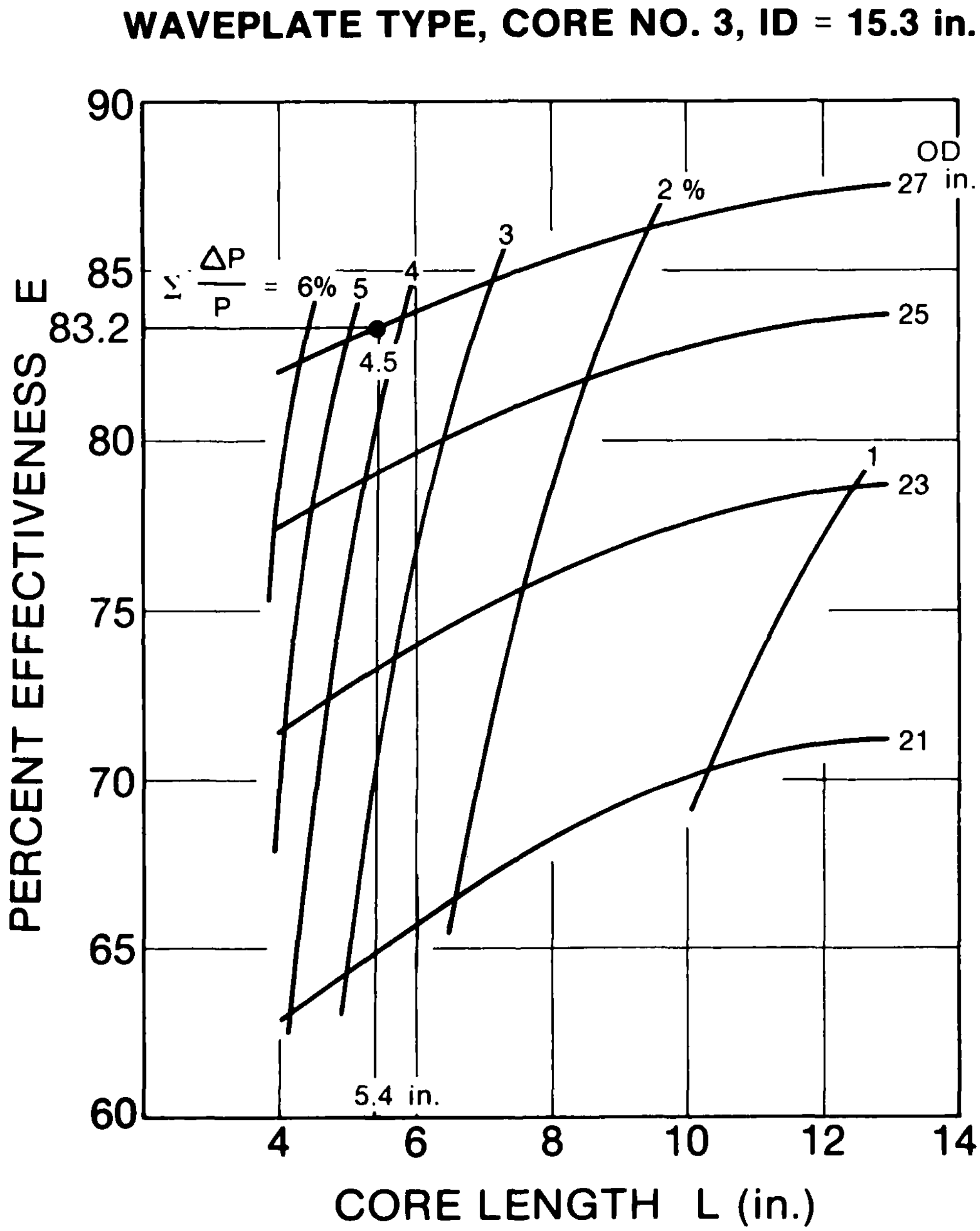


Figure 16. Waveplate recuperator performance map, preliminary cycle M

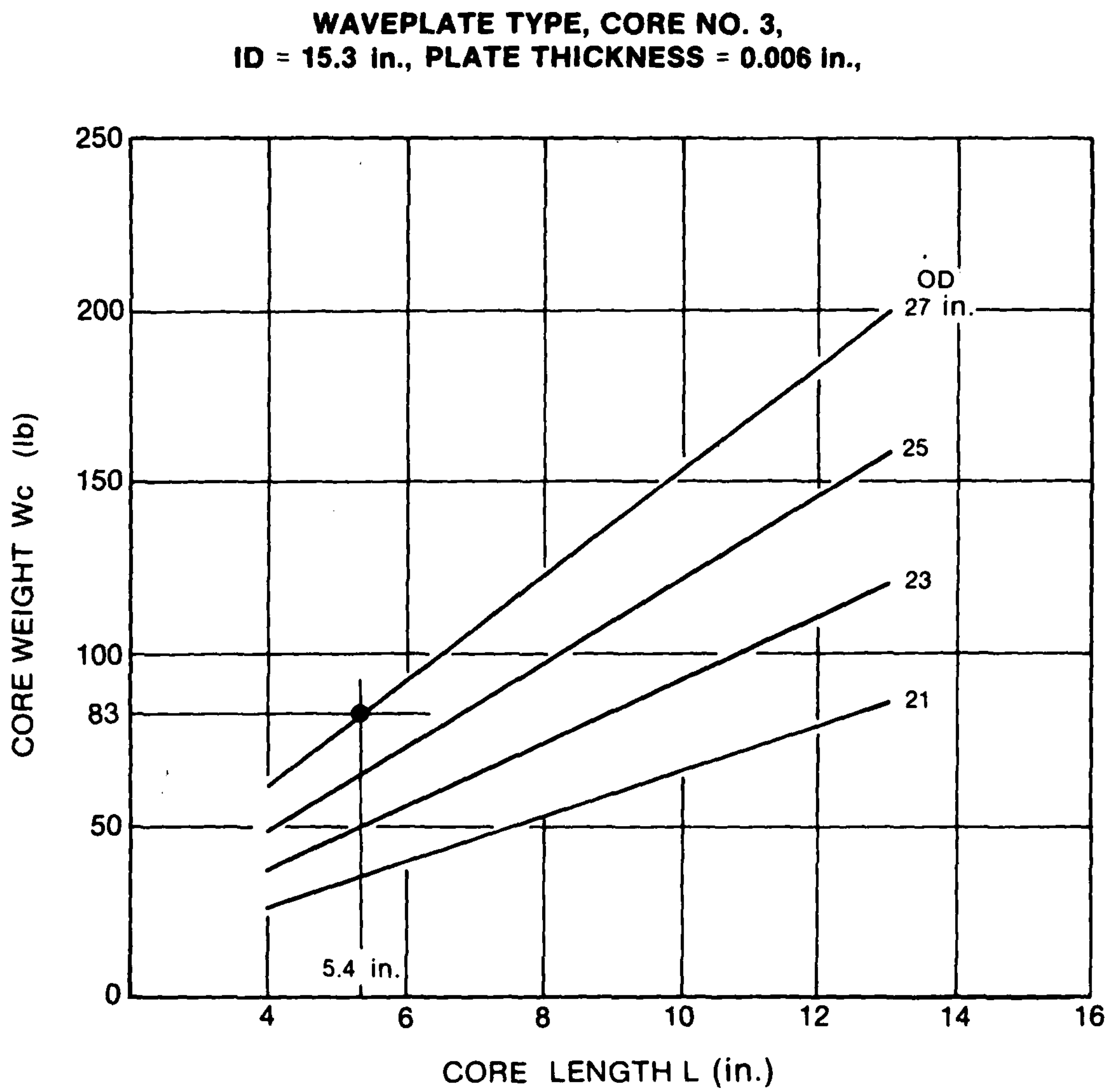


Figure 17. Waveplate core weight

trade-off varies with the effectiveness level, but it is of the order of 1 effectiveness point for 1 percent total pressure loss; i.e., the effectiveness in this case can be decreased to .822 if the total pressure loss is reduced to 3.5%. This yields a core with 26-inch outer diameter, 6.2-inch length, and 84-pound weight. The design with 27-inch outer diameter and 5.4-inch length thus in this case is close to minimum weight. In general, minimizing core weight through $E - \Sigma \Delta P/P$ trade-off yields a gain of only a few pounds, which has been disregarded for the parametric study. The waveplate core weights have been determined in the same manner for the effectivenesses that correspond to $\Sigma \Delta P/P$ = 4.5% and outer core diameters of 25, 23, and 22 inches (E = .784, .718 and .68, respectively).

b) Tubular Designs

Similarly, the weights of the tubular cores have been determined for the same cycle point data and 15.3-inch inner diameter. For the entire effectiveness range, the U-tube configuration with single cross-flow gas path has been found to be the lightest design concept. In general, the staggered geometry X_T = 1.25 D, X_L = 1.0 D also yields minimum weight within the range $\Sigma \Delta P/P$ = 3-5%. Figures 18 and 19 show the performance and the weight of a core made of .10-inch diameter U-tubes of .004 inch-thickness and dimple parameter ε/D = .105 which yields minimum weight for the highest attainable effectiveness level of .8-.85. The intersection of the line $\Sigma\Delta/P/P$ = 4.5% with the 21.3-inch outer diameter line gives E = .815, L = 8.5 inches, and 32 pounds. Extrapolation toward the 20.3-inch outer diameter yields E = .80, L = 10 inches, and 27 pounds. For the .75 effectiveness level, a minimum weight of 19 pounds is obtained with .15-inch diameter tubes and a dimple parameter ε/D = .155 (Figure 20), and .15-inch-diameter tubes with ε/D = .105 yield a minimum weight of 8-11 pounds for .62-.68 effectiveness (Figures 21 and 22). The corresponding U-tube number is given by Figure 23.

The results are plotted on Figure 24, which shows the tubular core to be markedly lighter than the waveplate core for the entire effectiveness range. The tubular recuperator thus has been selected for the entire parametric study.

The weights shown on Figure 24 pertain to a series of cores designed for one set of air and gas flow rates at given inlet temperatures and pressures and with a 15.3-inch inner core diameter (reference cores). If the core dimensions are assumed to be essentially determined by the gas mass flow rate, approximate core weights for all parametric cycle points can

DIMPLED U-TUBE TYPE, ID = 15.3 in.
TUBE DIAMETER D = 0.10 in., ε/D = 0.105

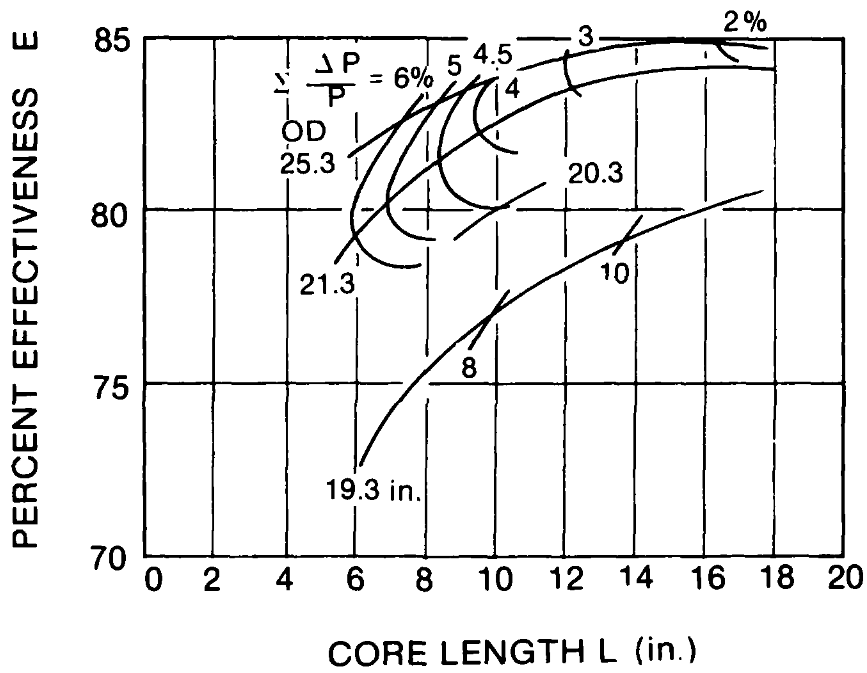


Figure 18. Tubular recuperator performance map, preliminary cycle M

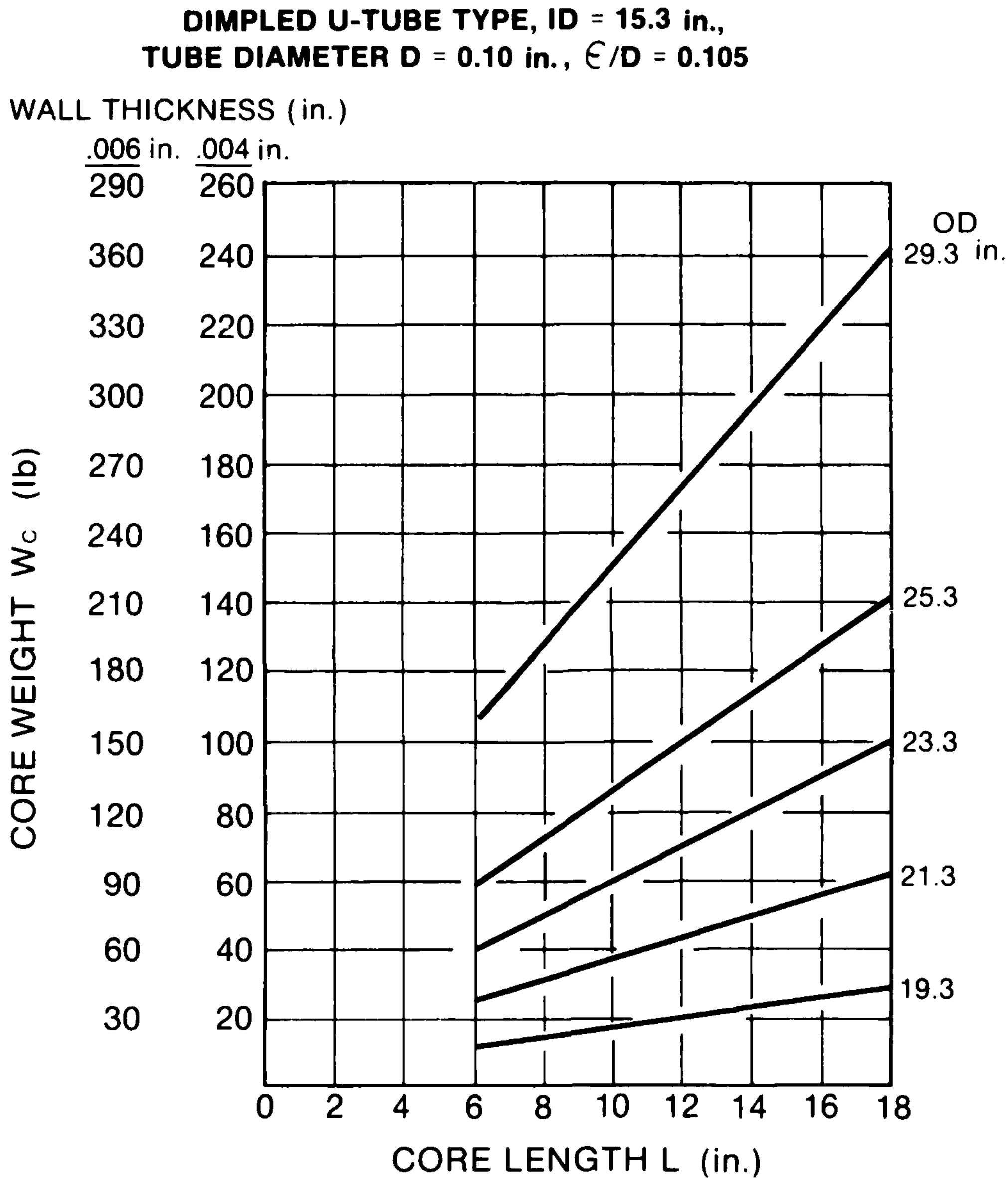


Figure 19. Tubular core weight

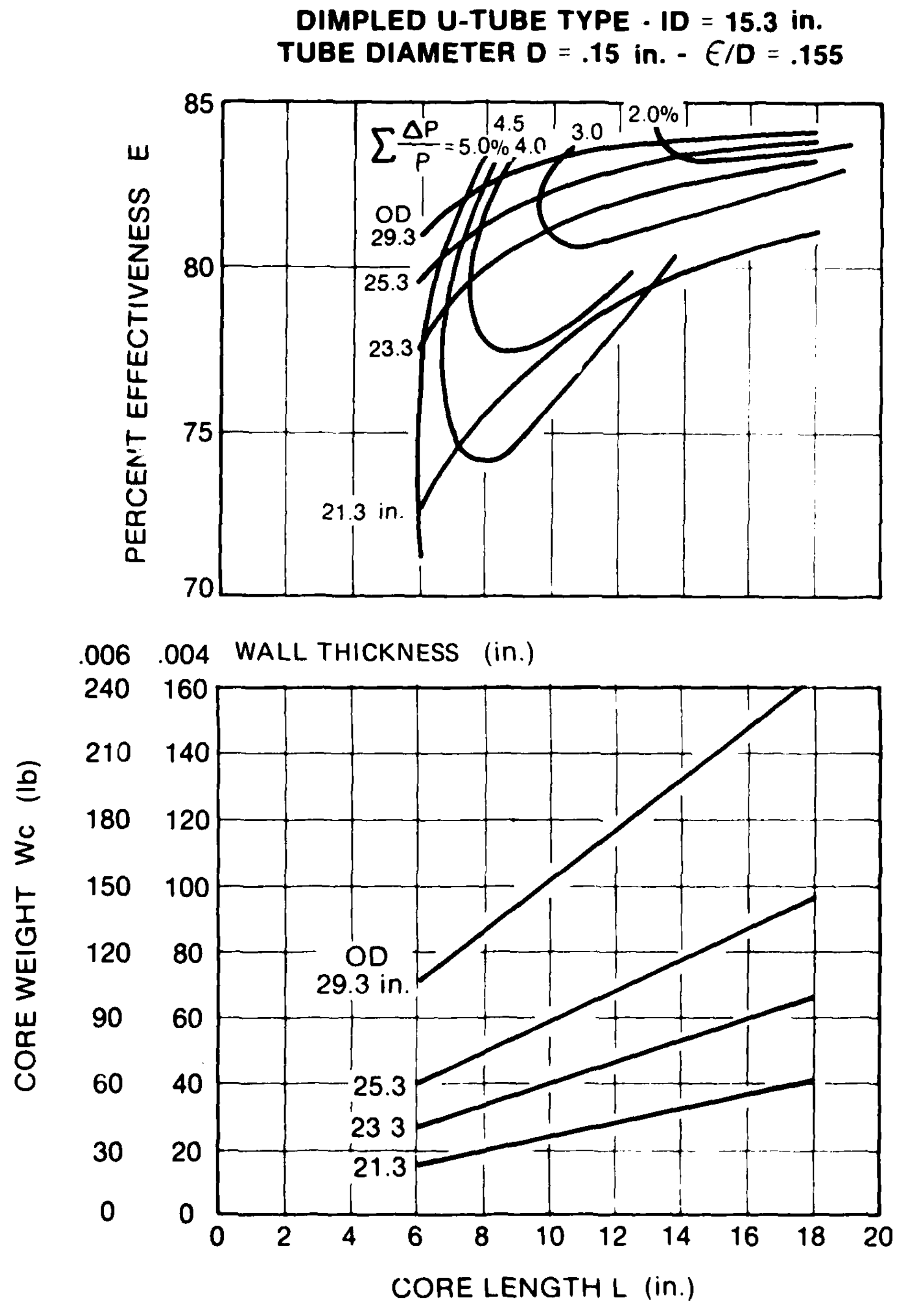


Figure 20. Tubular recuperator performance map and core weight, preliminary cycle M

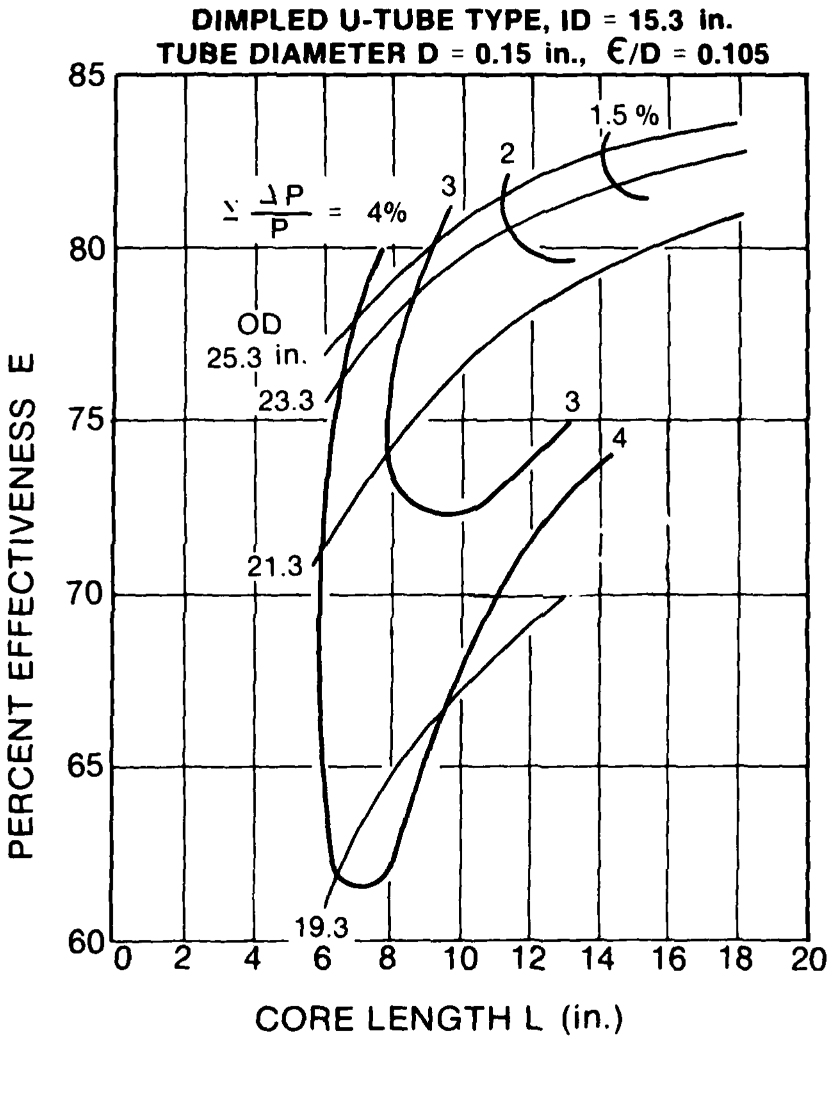


Figure 21. Tubular recuperator performance map, preliminary cycle M

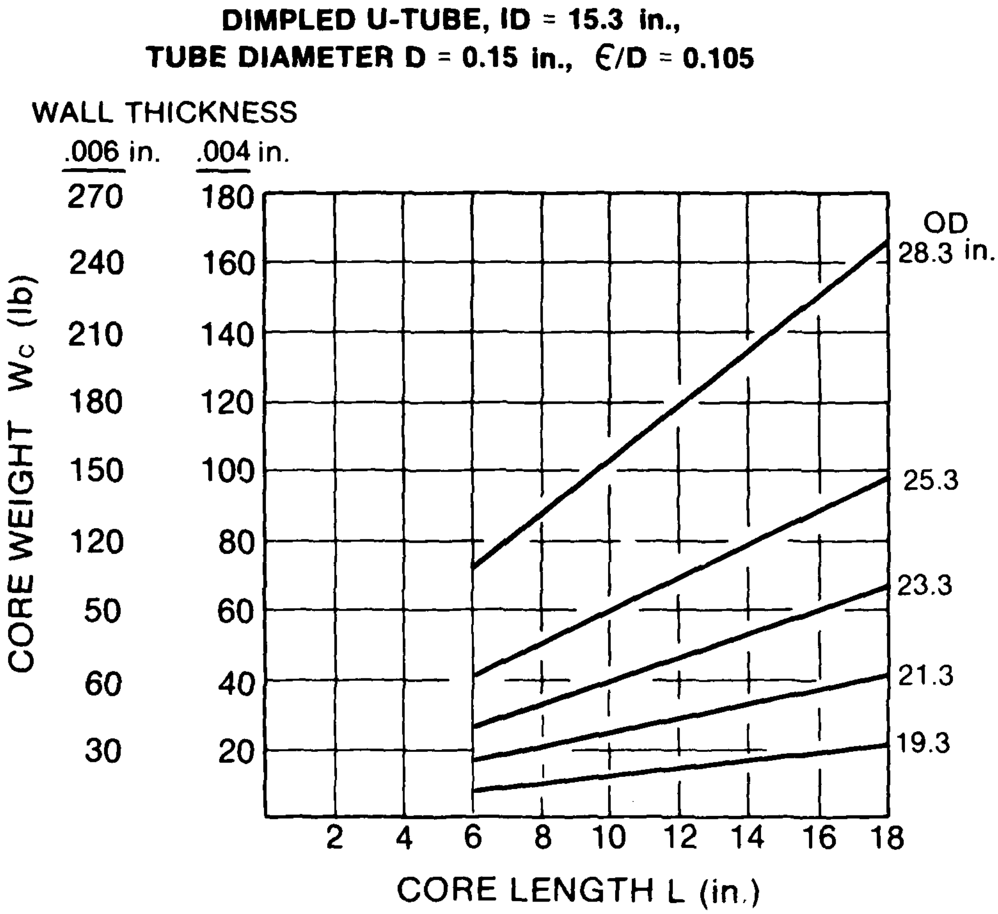


Figure 22. Tubular core weight

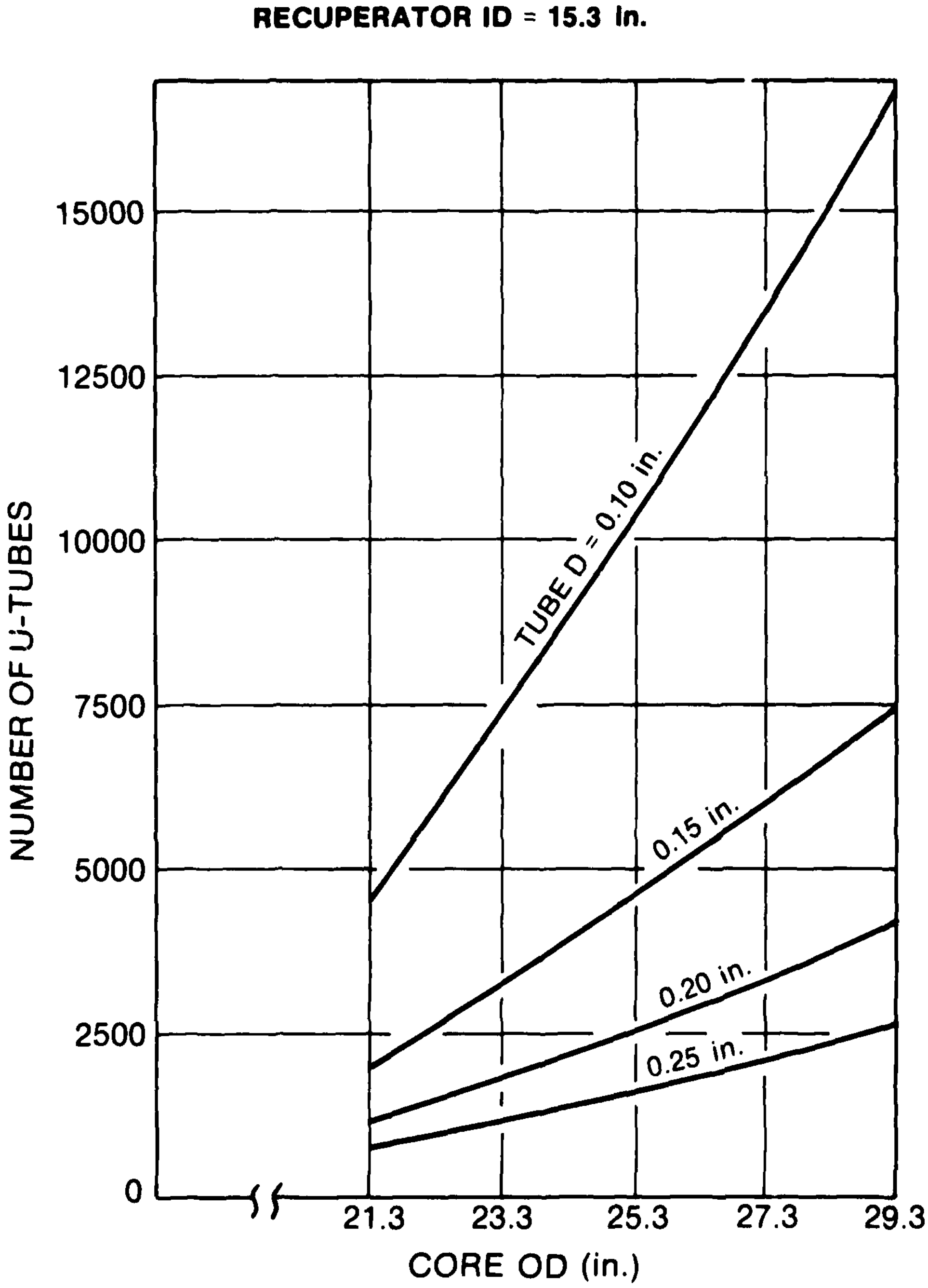


Figure 23. U-tube number

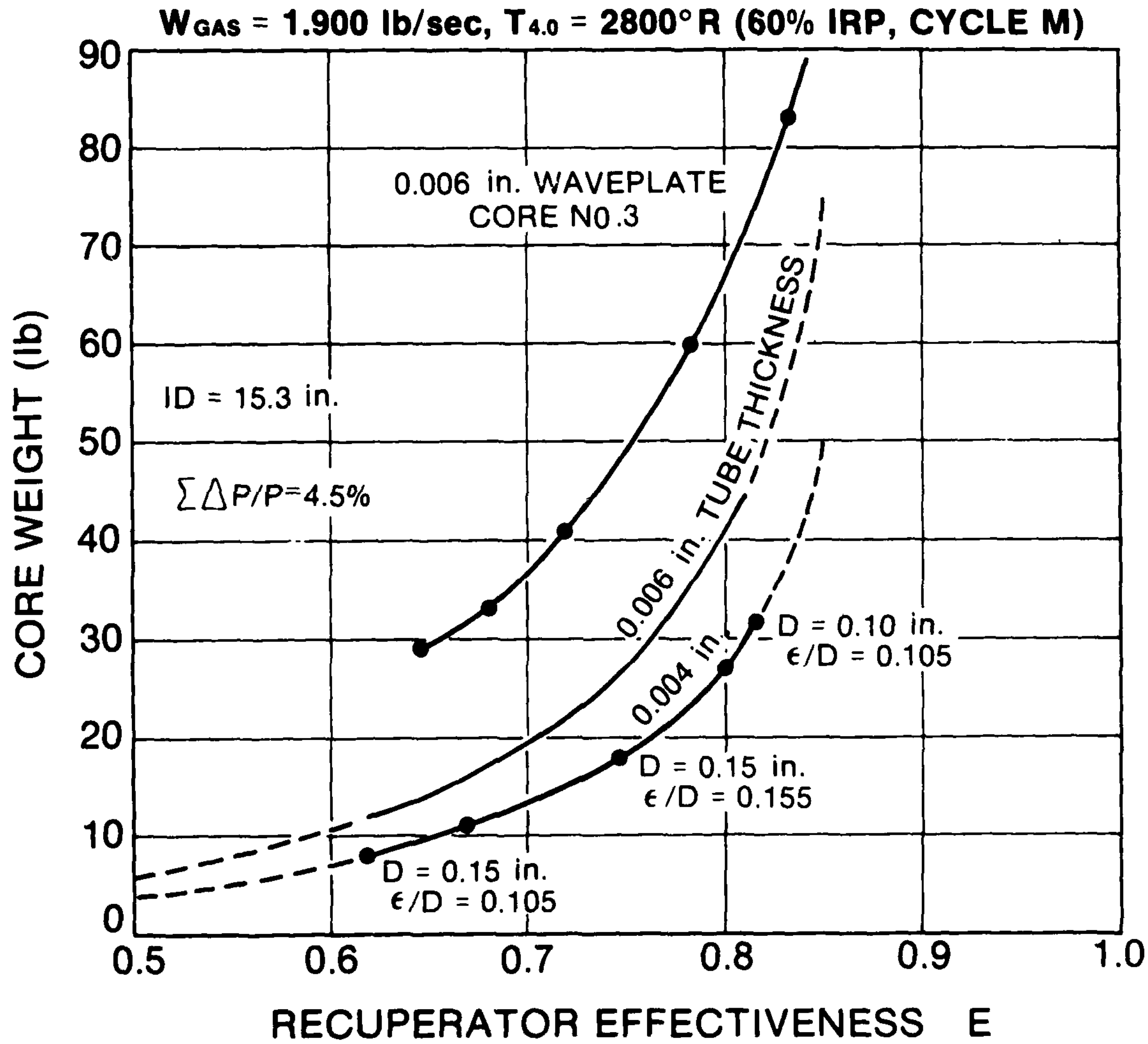


Figure 24. Recuperator core weights, preliminary cycle M

then be calculated by means of a direct proportion of the referred mass flow rates of the actual and the reference cores.

The weight of the envelope is determined according to the assumption of Engine Weights for one reference recuperator, and the ratio of total recuperator to core weight is assumed to remain constant for all parametric recuperators. These calculations have been carried out for a reference recuperator with E = .75 and a core weight of 19 pounds as shown in Figure 24. This yields a wrap-up weight of 33 pounds thus a total recuperator weight of 52 pounds (recuperator/core weight factor of 52/19 = 2.74).

Engine + Mission Fuel Weight

The recuperator weights have been entered in Table 4 together with the basic engine and the mission fuel weights. The sum of total engine plus mission fuel weight is shown in the last column. Figure 25 shows the plots of engine + mission fuel weights vs recuperator effectiveness for the three 60% IRP cycle temperatures. The curves exhibit a minimum in the .5-.6 effectiveness range. Clearly, Cycles J, K and L with E = .5 are not competitive with Cycles G, H and I, respectively, with E = .65, since for practically equivalent engine + mission fuel weights, their life mission fuel consumption according to Figure 15 is of the order of 7% higher, resulting in an additional fuel consumption of (260-243) · 2500 = 42,500 pounds for an engine mission life of 5000 hours. On the other hand, effectiveness levels in excess of .8 result in heavy recuperators that prohibitively penalize engine + mission fuel weight for all cycle temperatures.

From the results of the preliminary parametric analysis, it appears that cycles with 60% IRP temperatures below 2300°R and recuperator effectivenesses lower than .6 and higher than .8 are not competitive.

TABLE 4. PRELIMINARY PARAMETRIC CYCLE DATA AND ENGINE + MISSION FUEL WEIGHTS

Cycle	Cycle Temperature $T_{4.0}$ (°R)		Cycle Pressure Ratio		Recuperator Effective-ness E	Weights (lb)			
	60% IRP	IRP	60% IRP	IRP		Basic Engine	Recup-erator	Mission Fuel	
A	2200	2370	4.3	5.7	0.85	183	230	217	630
B	2400	2570	5.4	7.4		152	187	211	550
C	2600	2770	6.5	9.2	0.85	139	166	217	522
D	2200	2370	5.7	7.8	0.75	173	78	238	489
E	2400	2570	6.8	9.6		148	66	229	443
F	2600	2770	7.9	11.4	0.75	138	61	231	430
G	2200	2370	6.8	9.5	0.65	172	39	255	466
H	2400	2570	8.0	11.5		148	34	243	425
I	2600	2770	8.5	12.4	0.65	138	32	243	413
J	2200	2370	8.2	11.7	0.5	176	15	276	467
K	2400	2570	8.5	12.3		149	13	260	422
L	2600	2770	8.5	12.4	0.5	137	13	259	409
FC*	2387	2770	7.0	8.7	0.75	142	73	250	465

* Cycle Optimized for Constant Power Turbine Geometry.

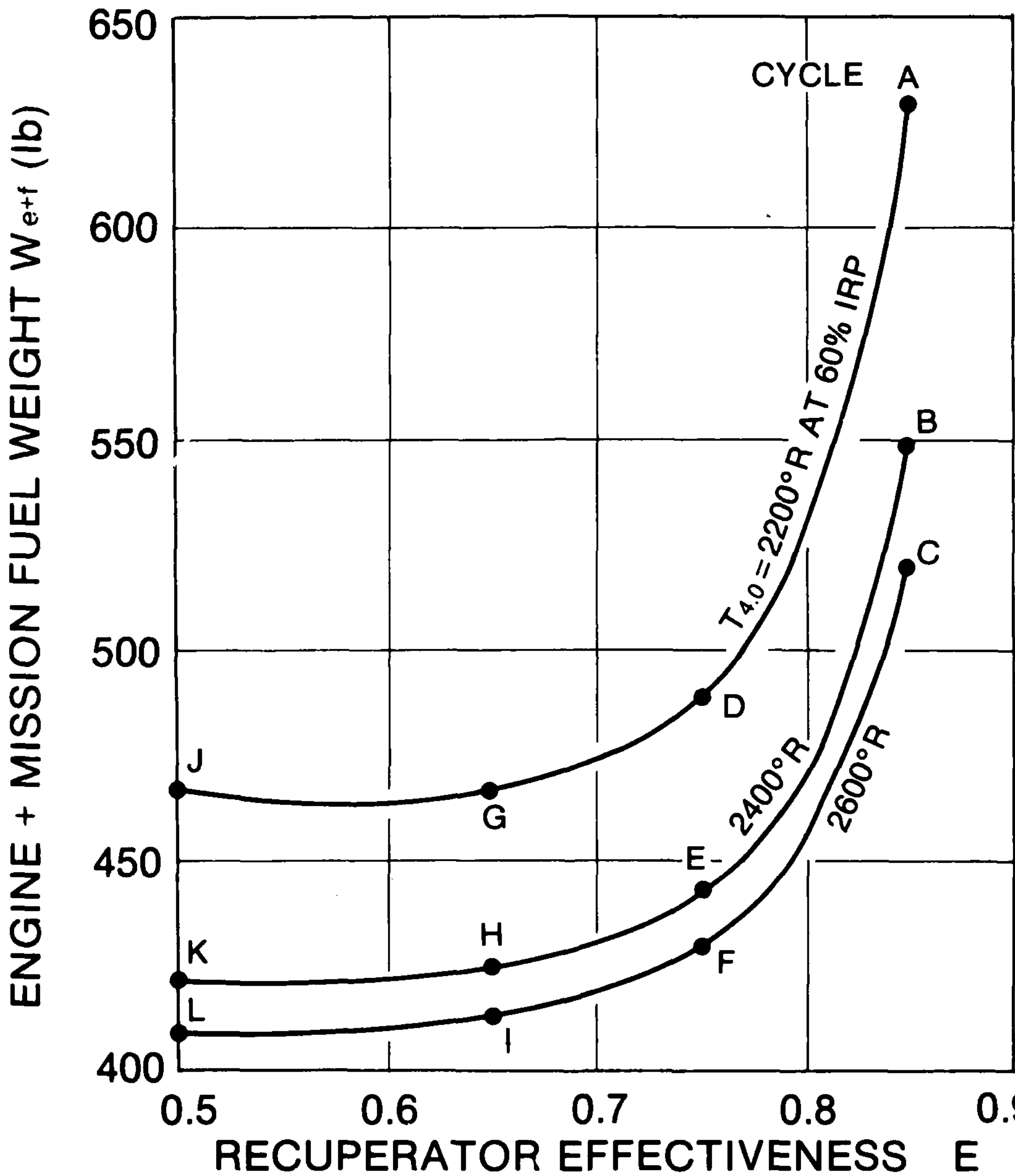


Figure 25. Engine + mission fuel weight with tubular recuperator

REFINED FARAMETRIC ANALYSIS

CYCLE MATRIX

As a result of the preliminary cycle analysis, three 60% IRP temperatures $T_{4.0}$ = 2300, 2450 and 2600°R, and three recuperator effectivenesses E = .6, .7 and .8, have been selected for the refined parametric analysis. The matrix of the 9 cycles is shown on Figure 26. The cycles are identified by numbers 1-9. The pressure ratio limitation of 8.5 at 60% IRP has been retained in order to minimize PR upscaling of the basic map. Referring to Figure 2, reference point C has been selected for all cycles in order to increase the surge margin to approximately 10% in the critical 40-60% IRP range.

COMPONENTS PERFORMANCE ASSUMPTIONS

Compressor Efficiency

In general, the polytropic efficiency decreases with increasing pressure ratio. This is especially the case for a small engine, for which the small blade height of the rear stage results in aerodynamic losses that increase markedly beyond a pressure ratio of 7-10. The 60% IRP polytropic efficiency has been assumed to decrease from .85 to 5.5 PR to .83 at 8.5 PR according to:

$$\eta_{p_c} = 0.85 \cdot [1-0.04314\,(PR/5.5-1)] \qquad (2)$$

Turbine Efficiency

For constant inlet temperature, the polytropic efficiency of a turbine stage decreases with increasing expansion pressure ratio, so that the adiabatic efficiency tends to remain constant over a substantial range of stage pressure ratio. However, as a result of the aerodynamic blade design compromise necessary to accommodate cooling provisions, the adiabatic efficiency of an air-cooled stage tends to decrease with increasing inlet temperature. Based on current experience, the design adiabatic efficiency of the gas producer turbine stage is assumed to be .87 for $T_{4.0}$ = 2300°R at 60% IRP and to decrease linearly to .86 at 2600°R.

It is further assumed that the adiabatic efficiency is essentially a function of the isentropic specific work coefficiency $\Psi = \Delta H_{is}/U^2$ and that maximum efficiency occurs at the design point, i.e., with Ψ_{des}.

For off-design conditions, performance analysis gives power hp, mass flow rate W_g and rpm with a tentatively assumed efficiency η_{ad}. For each condition, $\Psi = \text{Const} \cdot \text{hp}/W_g\ \eta_{ad}\ \text{rpm}^2$ is calculated and a reference optimum speed $\text{rpm}_{ref} = \text{rpm}\sqrt{\Psi/\Psi_{des}}$ is determined.

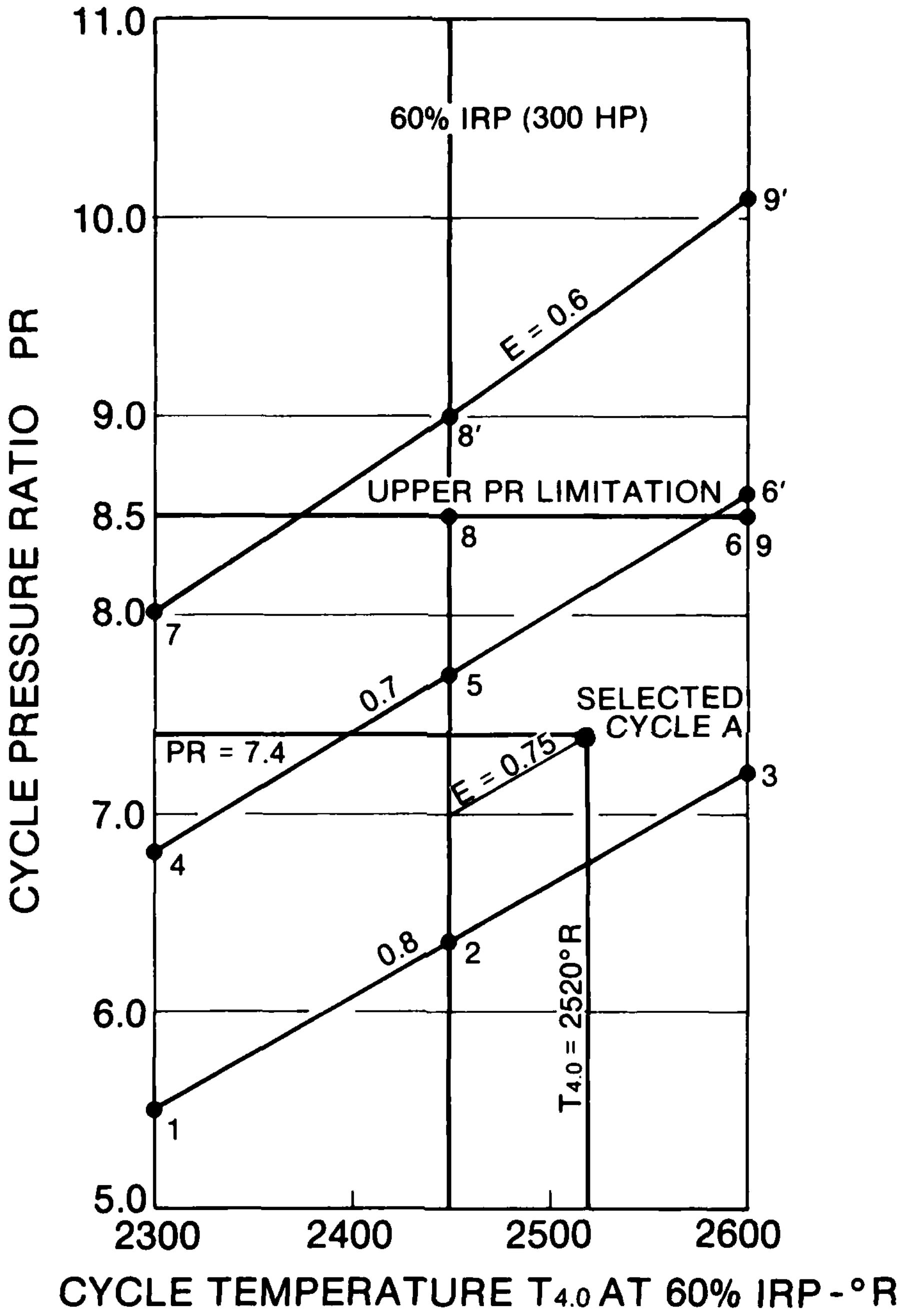


Figure 26. Cycle matrix for referred parametric analysis

The off-design efficiency, then, is calculated iteratively from the relation

$$(\eta/\eta_{des})_{ad} = 1 - (rpm/rpm_{ref} - 1)^2 \qquad (3)$$

For the gas producer turbine, the excursion from optimum rpm is negligible over the entire operating range. On the other hand, the constant speed power turbine is subjected to large excursions from optimum rpm. Furthermore, its efficiency varies as a result of the additional losses due to the variable stator geometry. It is, therefore, essential to minimize those losses by selecting a design point between part power and IRP. The selected design point is at 375 hp (75% IRP) with an adiabatic efficiency of .88. That value is assumed to decrease linearly to .86 at the closed and the opened stator settings corresponding to 275 hp (55% IRP) and IRP for optimum rpm conditions. Relation (3) then is used to calculate the actual efficiency at constant 20,000 rpm over the entire operating range.

Recuperator Off-Design Effectiveness

The variations of effectiveness from the design values assumed at 60% IRP are calculated for the 50, 150, 275, 400, 500 and 550 hp points, and those refined and interpolated values are input in the performance analysis program. For the selected tubular recuperator type, the effectiveness varies only by ± 1-2 percentage points over the operating range.

DETERMINATION OF ENGINE WEIGHT

Equation (1) for the weight of the engine without recuperator, W_{e-r}, is retained. However, W_o is redefined as the weight of a basic representative 800 hp engine with uncooled gas producer turbine rotor ($T_{4.0}$=2200°R at IRP point) and the lowest cycle pressure ratio of the parametric engines (PR = 7.93 at IRP point, Cycle 1). The effect of cycle pressure ratio and temperature on compressor and turbine weight then is taken into account for the calculation of the actual parametric engine weights.

Effect of Compressor Weight

It is assumed that the lowest IRP cycle pressure ratio of 7.93 (Cycle 1) can be achieved with a 1A + 1C compressor design. For the representative 800 hp engine with a 2A + 1C configuration, the entire compressor section constitutes approximately 18% of the engine weight. The compressor weight breakdown is as follows: Stage 1: 23.8%, Stage 2: 23.6%, Centrifugal Stage: 52.6%. Removing the second stage thus decreases the engine weight by .18 x .236=4.25%. A linear increase of engine weight with pressure ratio is assumed between the two limits of 7.93 (Cycle 1) and 12.325 (Cycle 6), yielding

$$\Delta W/W_o = 0.967\ (PR_{IRP} - 7.930)\ \% \qquad (4)$$

Effect of Turbine Weight

Cycle temperature affects the weight of the turbine section only. The weight increase of an existing engine has been determined to be 1.94% for a cycle temperature increasing from 2200°R to 2390°R. An engine weight increase proportional to the square root of the temperature increment gives realistic extrapolated values for the higher temperature levels of the parametric engines. This yields

$$\Delta W/W_o = 6.601 \left[T_{4.0\ IRP}/_{2200} - 1 \right]^{0.5} \quad \% \qquad (5)$$

The weight of the gas producer turbine can be expected to increase with cycle pressure ratio. On the other hand, the combustor weight decreases with increasing cycle pressure ratio as a result of the decreasing combustor volume. Those effects are comparatively small, tend to cancel each other, and therefore are disregarded in the engine weight evaluation.

Engine Weight Formula

The weight formula for the parametric engines without recuperator thus is

$$W_{e-r} = W_o \left[1 + 0.00967 (PR_{IRP} - 7.930) \right] \left[1 + 0.06601 \left[T_{4.0\ IRP}/_{2200} - 1 \right]^{0.5} \right] \qquad (6)$$

Applying this formula to the representative 800 hp engine yields its basic weight W_o. This weight and the corresponding mass flow rate W_{a_o} define the proportionality factor in Equation (1) which now reads:

$$W_o = 40.1\ W_a \qquad (7)$$

Introducing this relation into Equation (6) finally gives the weight of the parametric engines

$$W_{e-r} = 40.1 W_a \left[1 + 0.00967 (PR_{IRP} - 7.930) \right] \left[1 + 0.06601 \left[T_{4.0\ IRP}/_{2200} - 1 \right]^{0.5} \right] \qquad (8)$$

in function of mass flow rate W_a, pressure ratio PR, and cycle temperature $T_{4.0}$ at IRP conditions.

Recuperator Weight

The core weights have been calculated for all nine tubular recuperators designed in the refined parametric study. Wrap-up weight also has been calculated for each core design. The total recuperator weight is added to W_{e-r} to yield the full engine weight W_e.

ENGINE DEVELOPMENT, ACQUISITION, AND MAINTENANCE COST

Simple formulas also are used to calculate the cost of development, acquisition, and maintenance of the parametric engines. The cost functions can be most conveniently expressed in terms of basic costs and incremental costs that are functions of the differences between the actual and the basic parameters. The latter functions can be quite generally expressed as exponentials. The basic and incremental costs are evaluated from existing engines. All costs are quoted in 1979 dollars.

Engine Development Cost

Development cost is broken down in components and full engine development cost. Components development cost is estimated on the basis of current test rig experience. Full engine development cost is estimated on the basis of the cost assessed for the basic representative 800 hp engine.

a) Compressor development cost is estimated to be \$700 K for the lowest IRP cycle pressure ratio of 7.93 (Cycle 1) and it escalates linearly to \$1 M for the highest pressure ratio of 12.325 (Cycle 6). This yields

$$C_{d_c} = 0.7[1+0.0975(PR_{IRP}-7.930)] \quad \$M \qquad (9)$$

b) Turbine development cost for each stage is estimated to be \$450 K for T=2200°R and it escalates quadratically to \$900 K at 2800°R. Thus,

$$C_{d_t} = 0.45\left[1+13.444(T/2200-1)^2\right] \quad \$M \qquad (10)$$

In this formula $T = T_{4.0}$ for the gas producer turbine and $T = T_{4.5}$ for the power turbine (stator inlet temperatures).

c) Burner development cost is estimated to be \$500 K for $T_{4.0} = 2200°R$ and escalates quadratically to \$750 K for $T_{4.0} = 2800°R$. This yields

$$C_{d_b} = 0.5\left[1+6.77(T_{4.0}/2200-1)^2\right] \quad \$M \qquad (11)$$

d) Recuperator development cost C_{d_r} is estimated to be \$500 K for all engines.

e) The development cost C_{d_m} of mechanical components (gears, bearings, seals) and accessories and the inlet particle separator is estimated to be \$1 M for all engines.

f) Engine development cost strongly depends upon the cycle temperature, and it has been estimated to be \$30 M for the basic 800 hp representative engine with $T_{4.0}$=2200°R. IRP $T_{4.0}$ is known for the actual representative engine, and assuming a quadratic escalation with temperature yields

$$C_{d_e} = 30 \left[1+12.653 \left[T_{4.0_{IRP}}/2200 - 1\right]^2\right] \qquad \$M \qquad (12)$$

<u>Engine Acquisition Cost</u>

Acquisition cost is estimated on the basis of the cost of the 100th representative 800 hp nonregenerative engine determined for 2500 engines at a production rate of 250 per year. The estimated recuperator cost then is added to yield the full regenerative engine cost.

For a given cycle temperature, the acquisition cost of the engine without recuperator is assumed to be directly proportional to its weight:

$$C_{a_{e-r}} = k \cdot W_{e-r} \qquad (13)$$

where W_{e-r} is given by Equation (8). Incremental costs are determined in function of the cycle temperature increments.

The incremental cost of an existing engine has been determined to be 3.18% for a cycle temperature increase of 190°R. The incremental engine cost is assumed to be proportional to the square root of the temperature increment. This yields

$$\Delta C_a = 10.81 \left[T_{4.0_{IRP}}/2200 - 1\right]^{0.5} \qquad \% \qquad (14)$$

Applying this formula to an engine with $T_{4.0}$= 2750°R results in an extrapolated incremental cost ΔC_a=5.41%, which is considered realistic. Factoring Equation (14) in Equation (8) yields the acquisition cost of the parametric engines without recuperator. The cost of Cycle 1 engine with $T_{4.0}$=2480°R, PR=7.93, and W_a=3.704 lb/sec at IRP has been estimated to be \$120,000.00. Introducing this value in the cost formula yields the

proportionality factor k = 0.760. Thus, finally:

$$C_{a_{e-r}} = 30.5W_a\left[1+0.00967(PR_{IRP}-7.930)\right]\left[1+0.0660\left[T_{4.0_{IRP}}/2200-1\right]^{0.5}\right]$$

$$X\left[1+0.1081\left[T_{4.0_{IRP}}/2200-1\right]^{0.5}\right] \qquad \$\,K \qquad (15)$$

Recuperator cost has been estimated for Cycle 5 with a core of 6.7-inch length, 2520 U-tubes, and 22-pound weight using standard materials and labor cost estimates for one unit and applying a learning curve slope of 80%. Inconel 625 material has been selected for the tubular core because of its outstanding corrosion resistance. Recuperator factored material cost is \$3174.00 and factored labor \$21,686.00. These costs include the exhaust gas collector. Cycle 5 recuperator cost thus is \$24,860.00.

For all parametric cycles, materials cost is assumed to be proportional to core weight and labor proportional to the number of tubes. The recuperator cost is added to $C_{a_{e-r}}$ to yield engine acquisition cost C_{a_e}.

Engine Maintenance Cost

Maintenance cost is assumed to be a function of IRP cycle temperature alone. It has been established for engines with Cycle 4 (IRP $T_{4.0}$ = 2500°R) and Cycle 6 ($T_{4.0}$ = 2845°R) and with the following assumptions:

Engine Total Production	2000 + 500 spares	
Production Rate	250/year	
Production Start	1985 (Calendar Year 1)	
Engine Maturity	1990 (Calendar Year 5)	
Mean Engine Life	5000 hr	
Duration of Program	1985-2005	
TBO during Maturing Period	Engine Cycle 4	Engine Cycle 6
(Calendar Year 1-5)	600 - 1000 hr	300 - 500 hr
	CY 1-5	1-5
On-Condition Maintenance for engines in operation beyond CY 5.		
Engine Fleet during CY 1-5:	70% of operational engines	
Engine Fleet during CY 6-15·	90% of operational engines	
Engine Utilization:	500 hr/yr	

With those assumptions, maintenance cost has been calculated as follows:

Engine Cycle 4	\$104,044.00/engine
Engine Cycle 6	\$111,889.00/engine

Assuming a quadratic escalation with temperature increase, this yields

$$C_m = 104.044 \left[1 + 3.959 \left(T_{4.0}/2500 - 1\right)^2\right] \$ K \qquad (16)$$

where $T_{4.0}$ is the cycle temperature at IRP.

RESULTS OF THE REFINED CYCLE AND RECUPERATOR ANALYSIS

Cycle Analysis

Table 5 lists the main characteristics of Cycles 1-9.

TABLE 5. PARAMETRIC CYCLE CHARACTERISTICS

	60% IRP (300 hp)				IRP (500 hp)			
Cycle	W_a (lb/sec)	PR	$T_{4.0}$ (°R)	E	W_a (lb/sec)	PR	$T_{4.0}$ (°R)	E
1	2.674	5,500	2300	0.800	3.704	7.930	2480	0.800
2	2.417	6.300	2450	0.805	3.351	9.186	2655	0.803
3	2.297	7.200	2600	0.817	3.167	10.401	2835	0.813
4	2.615	6.800	2300	0.701	3.641	9.897	2500	0.682
5	2.415	7.700	2450	0.702	3.350	11.189	2675	0.683
6	2.307	8.500	2600	0.694	3.188	12.325	2845	0.672
7	2.661	7.000	2300	0.633	3.685	10.162	2515	0.612
8	2.472	8.500	2450	0.591	3.382	12.229	2695	0.568
9	2.321	8.500	2600	0.613	3.194	12.286	2850	0.592

Figures 27-29 show the SFC's over the entire operating range for parametric Cycles 2-9. Figure 30 shows the compressor operating line for Cycle 5 as a typical example of the conditions obtained for the entire cycle matrix. Detailed Cycle 5 data are listed in Appendix A. All cycles use the compressor map consistently; i.e., all 60% IRP points correspond to point C of the basic map of Figure 2 with a 10% surge margin, and all IRP points fall between 94.5 and 95.5% of referred design speed. Variable power turbine stator geometry is used between 275 hp (55% IRP) and 500 hp (IRP) and cycle temperature $T_{4.0}$ increases linearly with power between those limits.

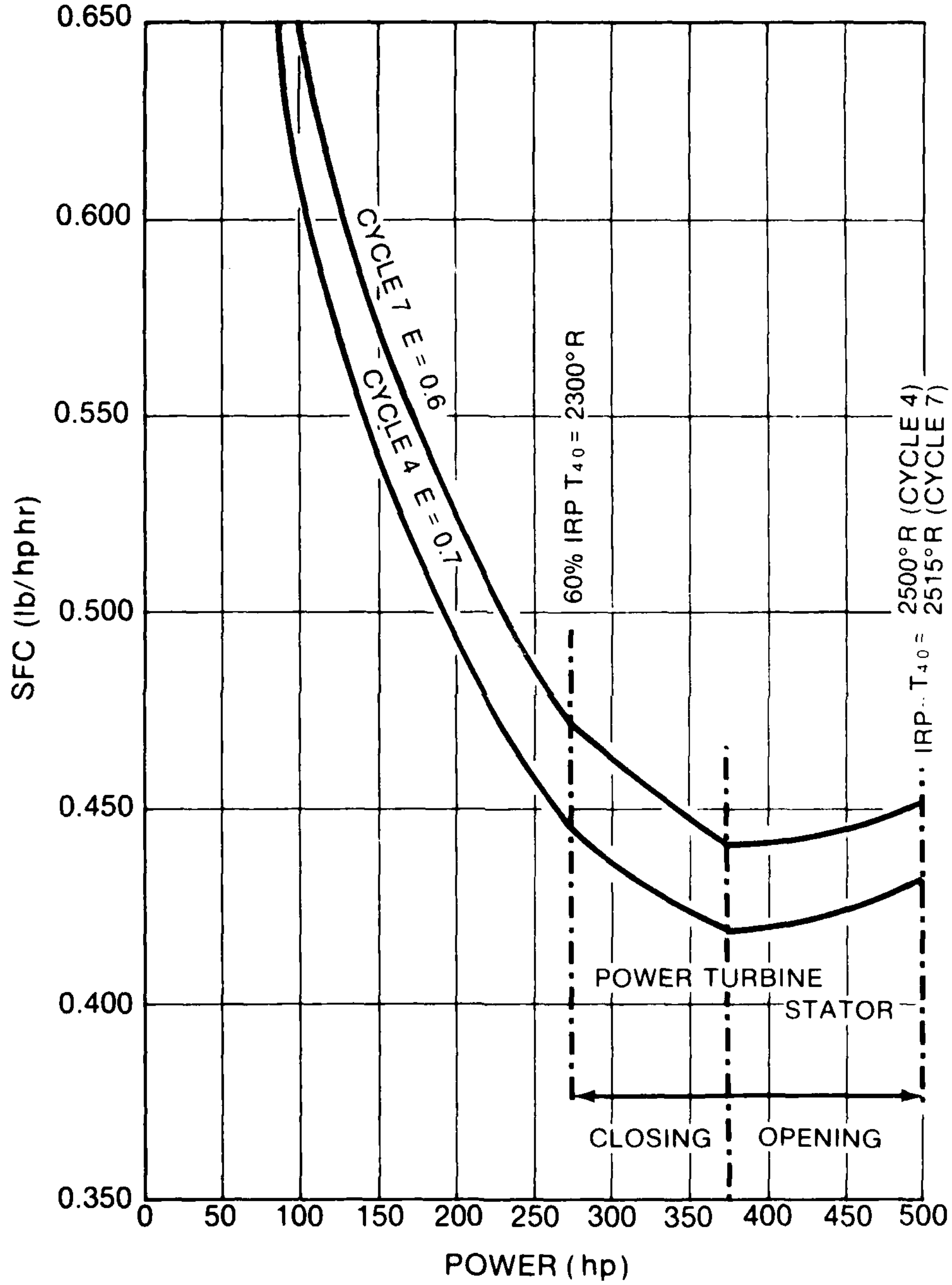


Figure 27. SFC comparison of cycles with $T_{4.0} = 2300^{o}R$ at 60% IRP

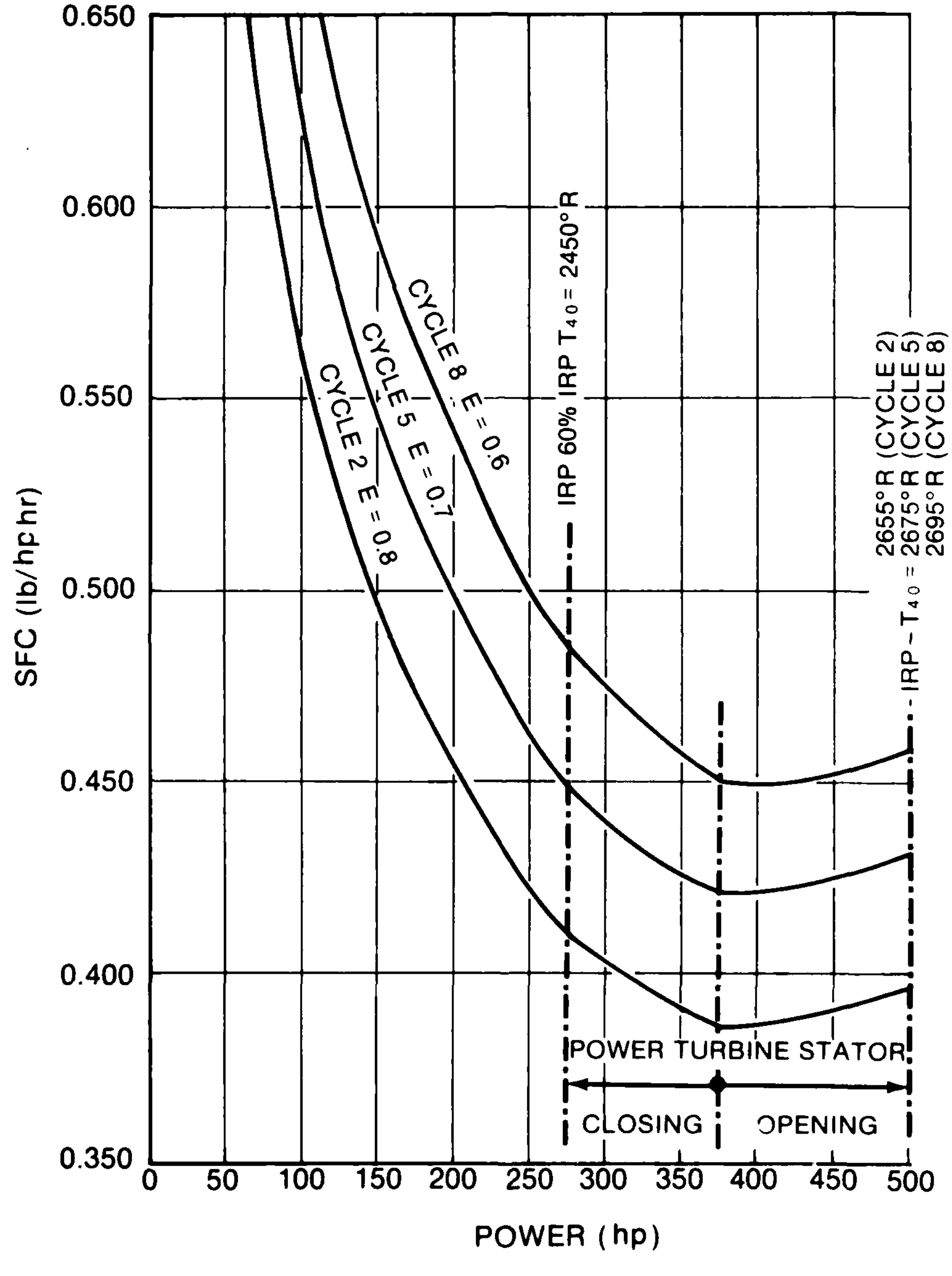


Figure 28. SFC comparison of cycles with $T_{4.0} = 2450^{\circ}R$ at 60% IRP

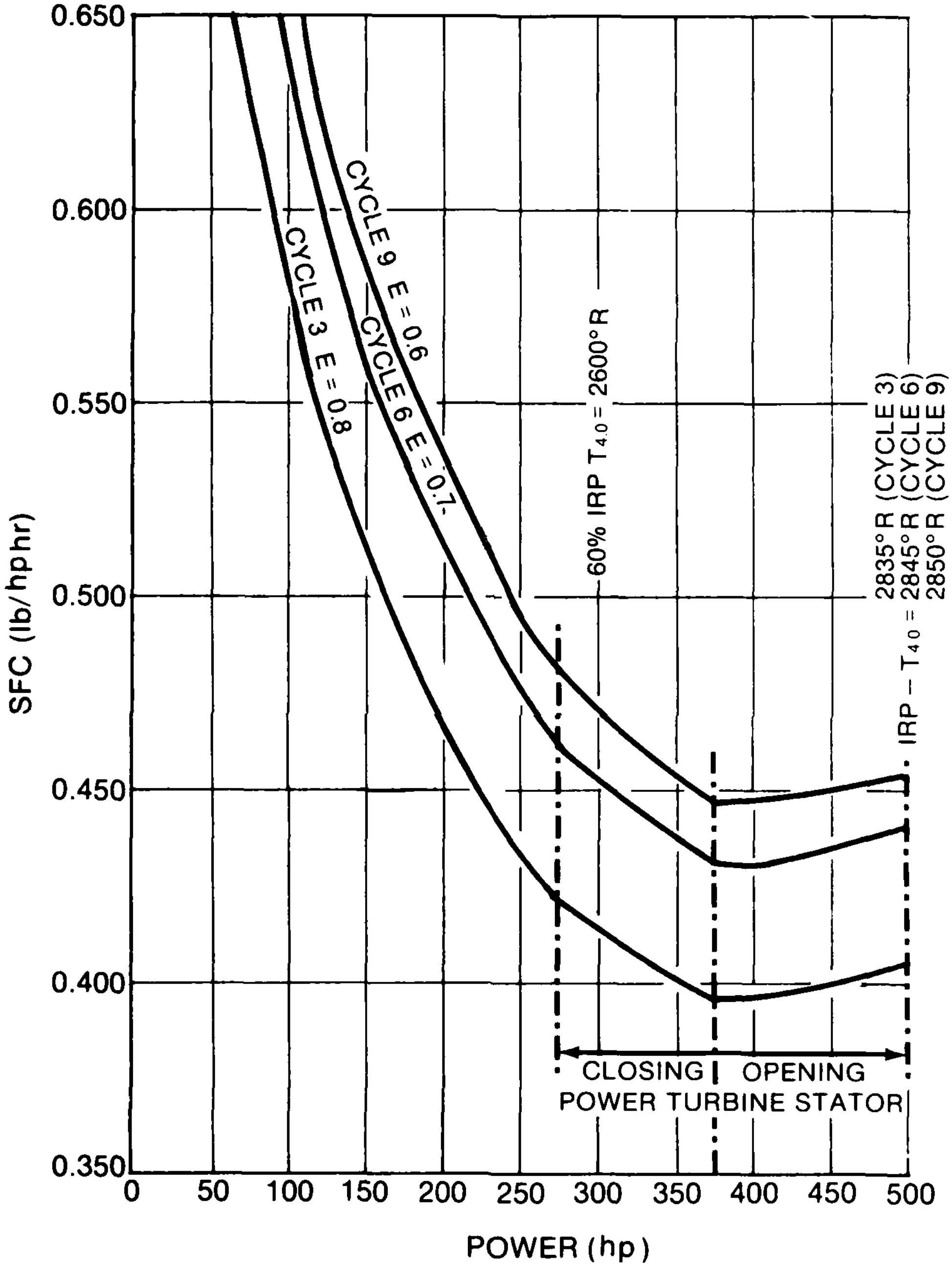


Figure 29. SFC comparison of cycles with $T_{4.0}$ = 2600°R at 60% IRP

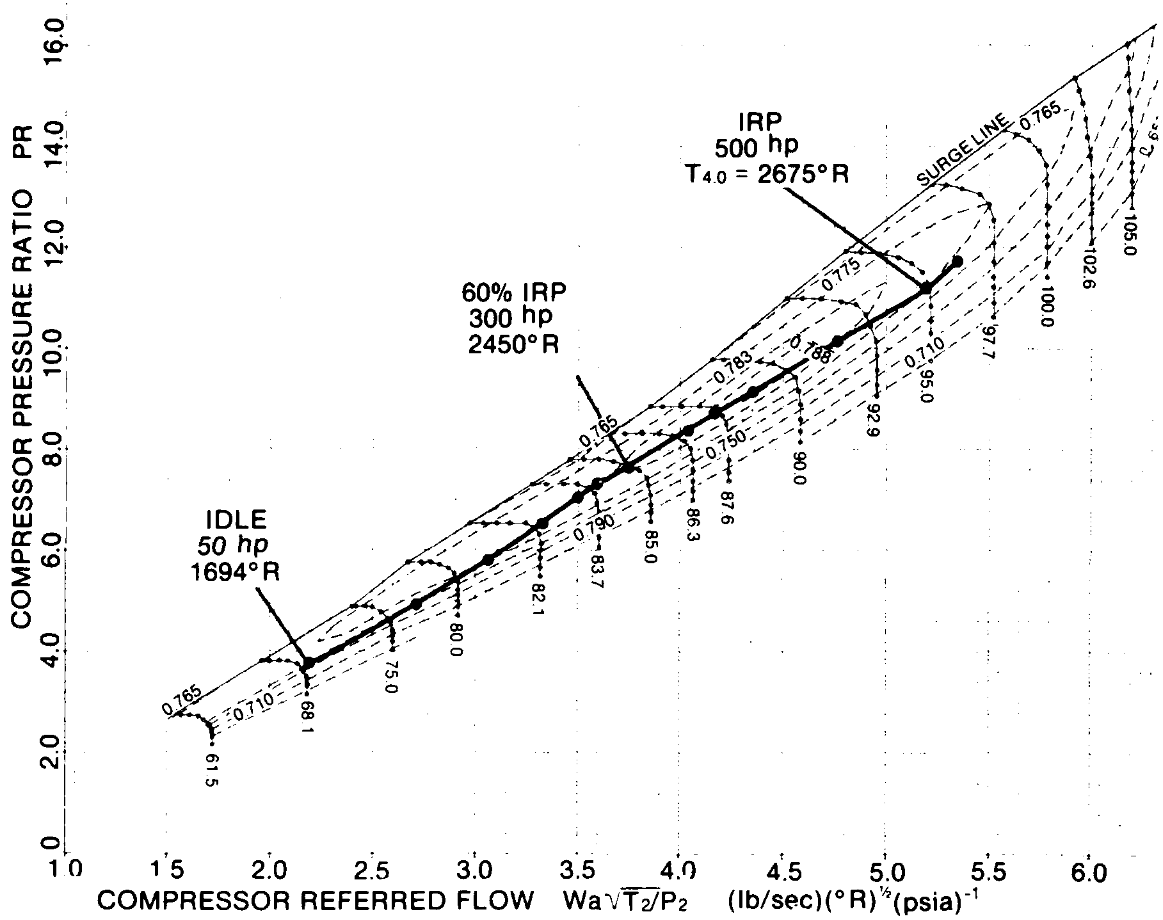


Figure 30. Operating line, cycle 5

Recuperator Design Analysis

Table 6 lists the 60% IRP aerodynamic design data. The calculation of the inner core diameters yielded values between 16.8 inches (Cycles 3, 5, 8) and 17.6 inches (Cycle 1). A common inner core diameter ID=17.2 inches was selected for the nine recuperators. In sizing the recuperator for Cycle 1, it was found that as a result of the low heat transfer coefficient on the comparatively low pressure air side, the required .8 effectiveness level could not be achieved without prohibitive core dimensions and weight.

TABLE 6. 60% IRP RECUPERATOR DATA FOR REFINED PARAMETRIC ANALYSIS

Core ID=17.2 inches

Cycle	AIR SIDE			GAS SIDE		
	P_{in} (psia)	T_{in} (^oR)	W_a (lb/sec)	P_{out} (psia)	T_{in} (^oR)	W_g (lb/sec)
1	80.02	915.6	2.564	15.00	1636.3	2.681
2	92.39	963.8	2.236	|	1662.7	2.448
3	104.75	1008.1	2.032	|	1666.8	2.403
4	98.93	987.1	2.502	|	1565.0	2.630
5	112.03	1033.8	2.225	|	1599.0	2.455
6	123.67	1072.4	2.067	|	1615.5	2.470
7	101.84	998.0	2.500	|	1555.1	2.636
8	123.67	1072.4	2.243	|	1468.8	2.483
9	123.67	1072.4	2.065	15.00	1613.6	2.477

For E = 0.80 (Points 1, 2, 3), tube diameter D = 0.1 inch and dimple factor $\epsilon/D = 0.105$ are optimum. Optimum design conditions for E = 0.70 (Points 4, 5, 6) are D = 0.15 inch and $\epsilon/D = 0.105 - 0.155$, and D = 0.15 inch and $\epsilon/D = 0.105$ for E = 0.60 (Points 7, 8, 9).

Table 7 lists the design characteristics of the eight recuperators (Cycles 2-9) retained for the parametric comparison.

TABLE 7. DESIGN CHARACTERISTICS OF THE TUBULAR RECUPERATORS

Core ID = 17.2 inches

Cycle	2	3	4	5	6	7	8	9
Effectiveness	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6
Core Length (in.)	12.5	10.0	8.2	6.7	6.5	6.0	5.4	6.0
Core OD (in.)	25.2	24.0	23.7	23.6	22.9	22.7	22.0	21.7
Tube Diameter (in.)	0.1	0.1	0.15	0.15	0.15	0.15	0.15	0.15
Tube Number	8100	6150	2500	2520	2100	1900	1500	1375
Core Weight (lb)	79.0	52.0	25.5	22.0	17.0	16.0	11.0	9.0
Recuperator Weight (lb)	131.8	97.6	65.5	59.1	52.2	49.9	42.7	40.8

Figure 31 shows the recuperator performance map for Cycle 1, which was deleted. Figures 32-34 show the recuperator performance map, core weights and tube number for Cycle 5 as a typical example. Detailed Cycle 5 recuperator design data are listed in Appendix B.

The required effectiveness E = .70 can be obtained with $\Sigma \Delta P/P$=4.5%, a core outer diameter of 23.8 inches, and a core length of 6.7 inches (point A), yielding a weight of 22 pounds with 2520 U-tubes. Equivalent cycle performance can be obtained with E = .695, $\Sigma \Delta P/P$ = 4.0%, yielding a core outer diameter of 23.3 inches, a core length of 7.2 inches (point B), a weight of 21 pounds, and 2480 U-tubes. The differences are insignificant for the purpose of parametric comparison.

Similarly, recuperator designs have been determined for the other cycles from the performance charts generated with the 60% IRP design data of Table 6. Based on the cycles with E=constant over the entire operating range, recuperator off-design effectiveness and total pressure loss have been calculated and the values used for refined cycle analysis. Table 8 shows the recuperator off-design performance for Cycle 5.

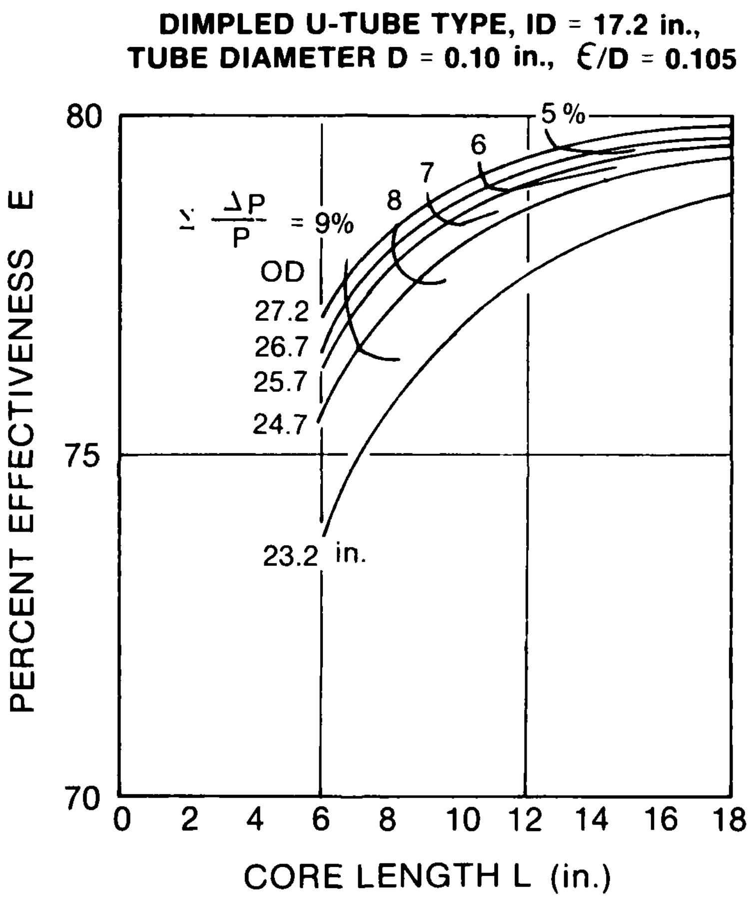


Figure 31. Tubular recuperator performance map, cycle 1

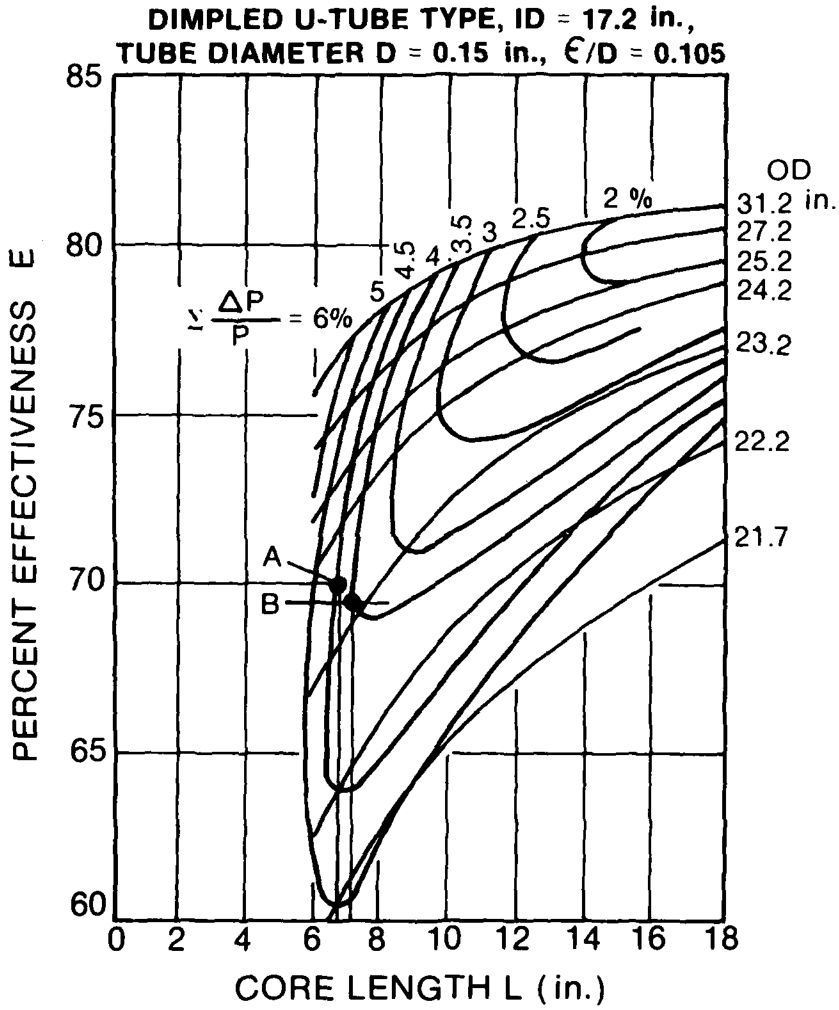


Figure 32. Tubular recuperator performance map, cycle 5

DIMPLED U-TUBE TYPE, ID = 17.2 in., TUBE DIAMETER D = 0.15 in.,
ϵ/D = 0.105, TUBE THICKNESS = 0.004 in.,

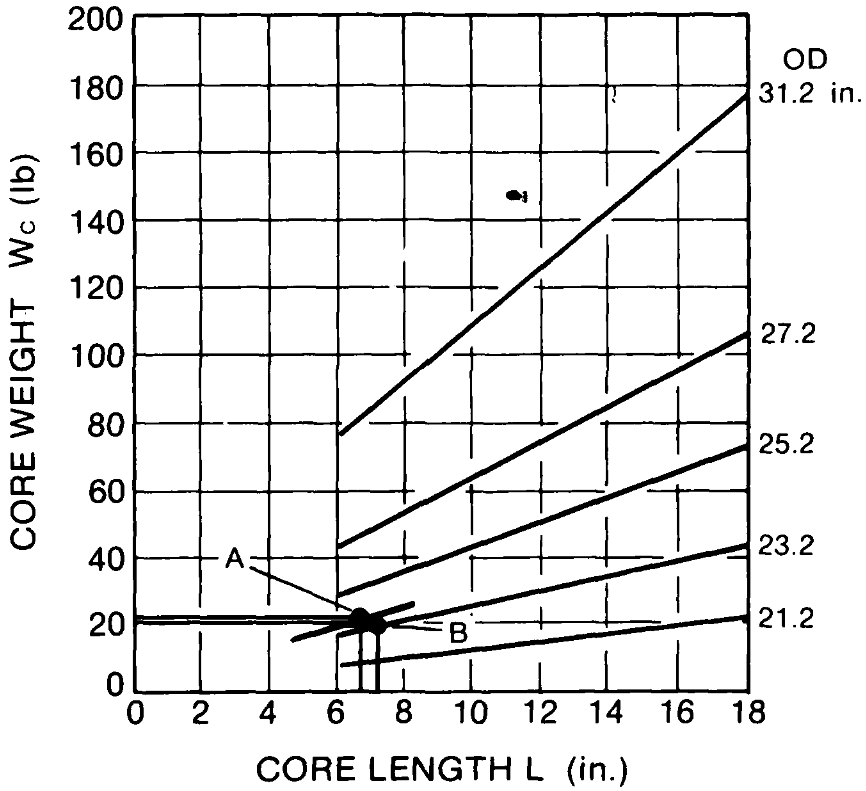


Figure 33. Tubular core weight, cycle 5

RECUPERATOR ID = 17.2 in., TUBE DIAMETER D = 0.15 in., ϵ/D = 0.105

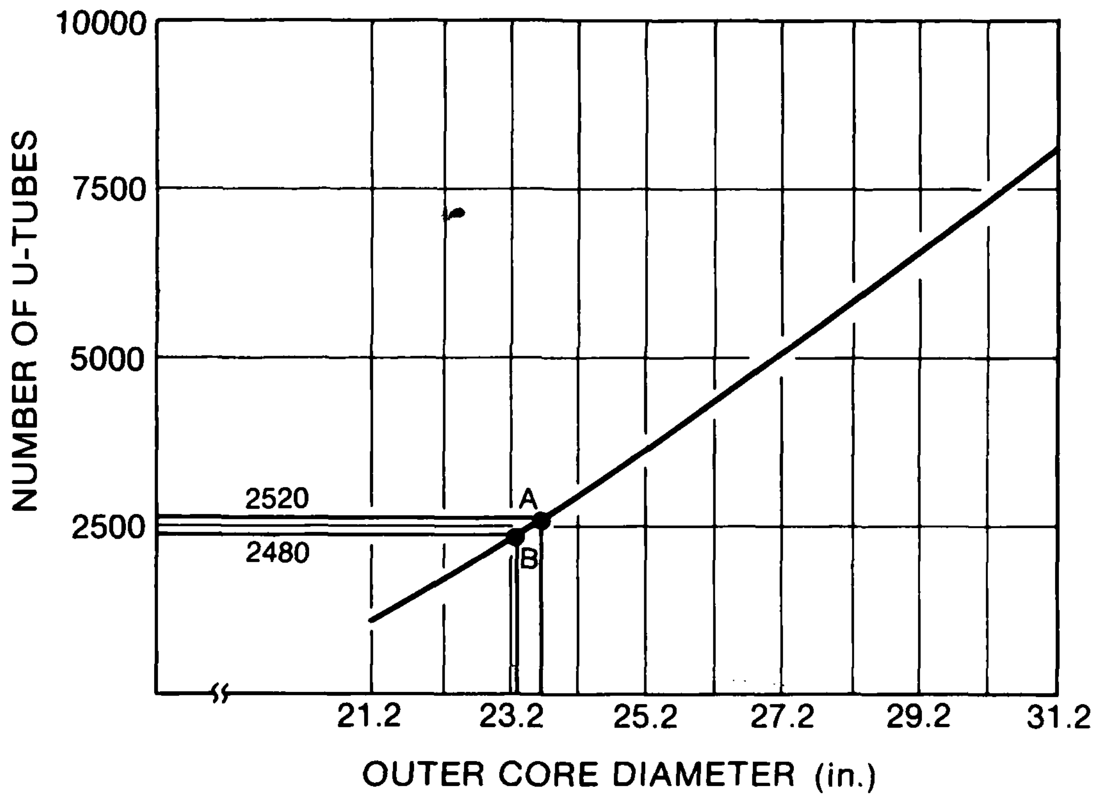


Figure 34. U-tube number

TABLE 8. RECUPERATOR OFF-DESIGN PERFORMANCE CYCLE 5

Power (hp)	50	150	275	300	400	500	550
E	0.7117	0.7060	0.7042	0.7017	0.6926	0.6825	0.6819
$\Sigma \Delta P/P$ %	2.08	3.25	4.27	4.53	5.69	7.35	7.94

Mission Fuel and Engine Weights

Taking the SFC data of Cycle 5 as an example, the following mission fuel consumption is calculated:

$$
\begin{aligned}
W_f &= 0.15 \cdot 50 \cdot 0.787 + 0.15 \cdot 200 \cdot 0.502 + 0.45 \cdot 275 \cdot 0.449 \\
&\quad + 0.20 \cdot 375 \cdot 0.421 + 0.05 \cdot 500 \cdot 0.432 \\
&= 118.9 \text{ lb/hr} = 237.8 \text{ lb/mission}
\end{aligned}
$$

The mission fuel weights have been plotted on Figure 35 for Cycles 2-9. The curve joining Cycles 7, 8 and 9 exhibits an inconsistent trend. This is due to the fact that, as a result of the recuperator design analysis, Cycles 8 and 9 were computed with $E = .5912$, $\Sigma\ \Delta P/P = 5.24\%$ and $E = .6133$, $\Sigma\ \Delta P/P = 4.72\%$, respectively, while the remaining cycles essentially retained the originally assumed effectiveness and pressure loss values.

Engine weight has been calculated as described in DETERMINATION OF ENGINE WEIGHT for Cycles 2-9. As a typical example, Cycle 5 yields the following IRP data:

$$W_a = 3.3497 \text{ lb/sec}, \quad PR = 11.189, \quad T_{4.0} = 2675^\circ R$$

The weight of the engine without recuperator follows from equation (8):

$$
\begin{aligned}
W_{e-r} &= 40.1 \cdot 3.349 \left[1 + 0.00967\,(11.189-7.930)\right] \\
&\quad \times \left[1 + 0.06601\,(2675/2200-1)^{0.5}\right] = 142.8 \text{ lb}
\end{aligned}
$$

Recuperator core weight is 22 pounds, and a wrap-up weight of 37.1 pounds

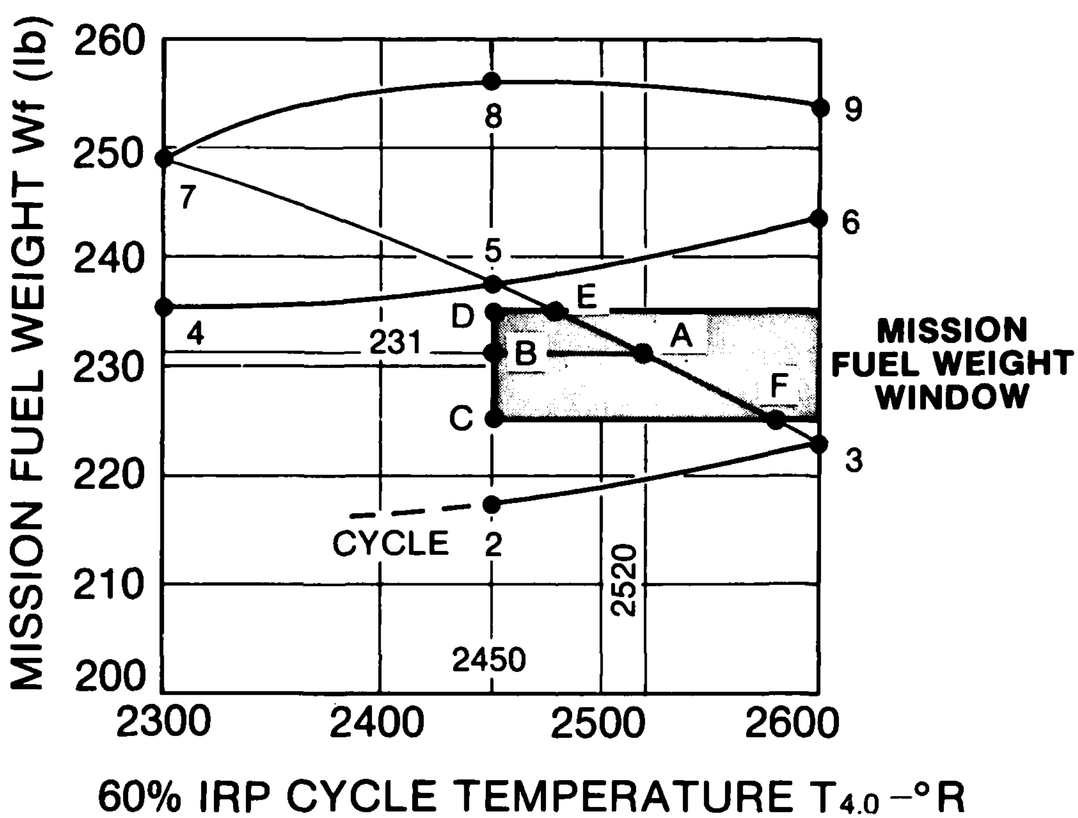


Figure 35. Mission fuel weight, cycles 2-9

has been calculated. Recuperator weight thus is 59.1 pounds and engine total weight W_e = 201.9 pounds.

Figure 36 shows the engine + mission fuel weight for Cycles 2-9. The engine and mission fuel weights also have been entered in Table 9, which shows that the lower mission fuel consumptions are obtained with the heavier engines (Cycles 2 and 3 with .8 effectiveness recuperators).

TABLE 9. ENGINE AND MISSION FUEL WEIGHTS

	WEIGHTS (lb)				
Cycle	Engine minus Recup-erator	Recup-erator	Total Engine	Mission Fuel	Engine plus Mission Fuel
1	-	-	-	-	-
2	140.1	131.8	271.9	217.3	489.2
3	134.6	97.6	232.2	223.1	455.3
4	152.4	65.5	217.9	235.5	453.4
5	142.8	59.1	201.9	237.7	439.6
6	138.0	52.2	190.2	243.7	433.9
7	154.7	49.9	204.6	248.9	453.5
8	145.7	42.7	188.4	256.2	444.6
9	141.3	40.8	182.1	253.5	435.6

Selection of Engine Cycle

In selecting the final cycle, a compromise must be made between minimum fuel consumption and minimum engine + mission fuel weight. For that purpose, a mission fuel weight window W_f = 225-235 pounds with a 60% IRP cycle temperature $T_{4.0}$ ranging from 2450 to 2600^{o}R and an engine + mission fuel weight window W_{e+f} = 432-450 pounds with an effectiveness range E = .68-.80 have been drawn in Figures 35 and 36. Candidate Cycles A, B, C, D, E, and F have been defined and located in both windows with the help of the interpolation curves of Figures 37 and 38. Cycles A,

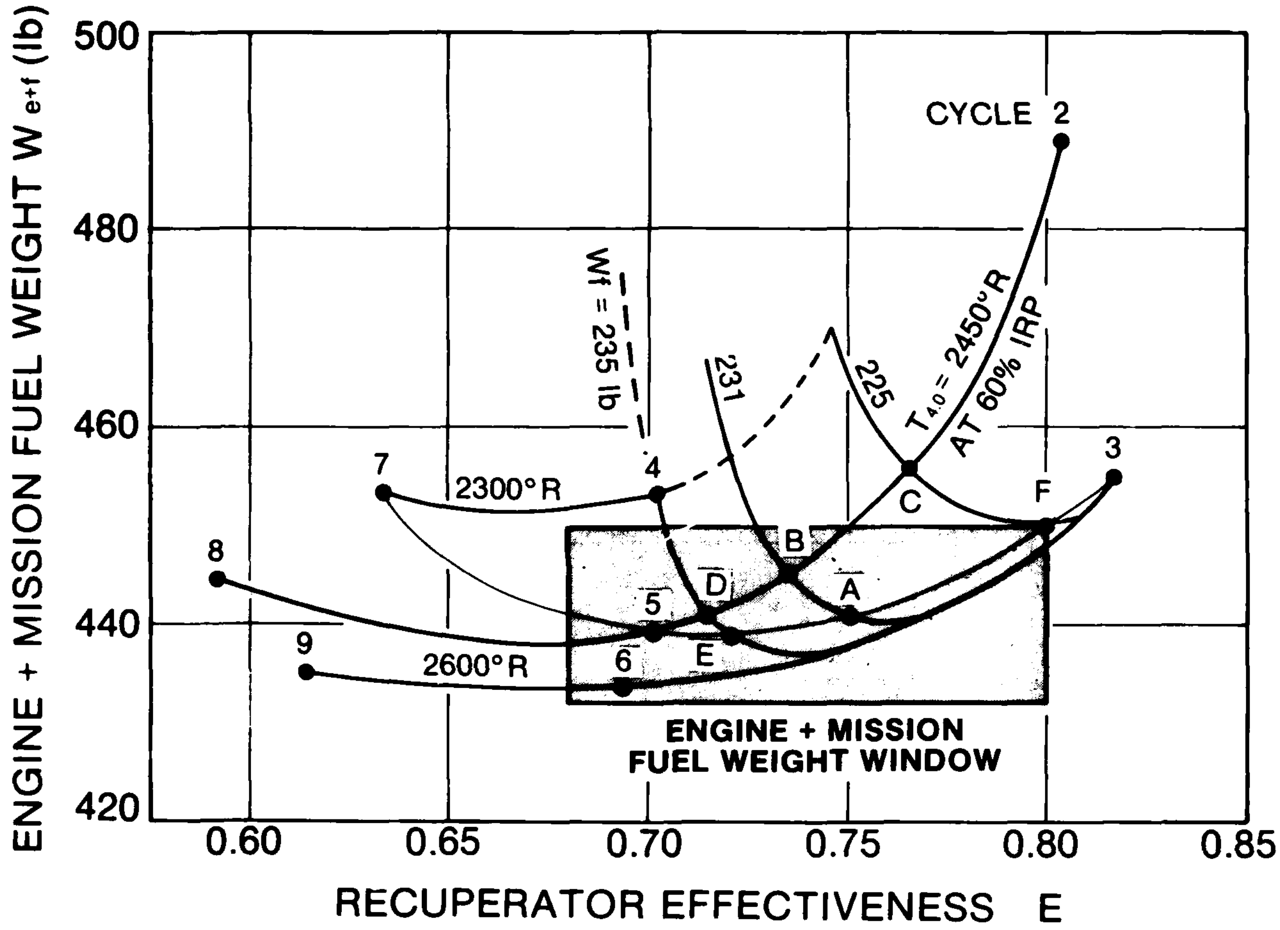


Figure 36. Engine + mission fuel weight, cycles 2-9

6
B

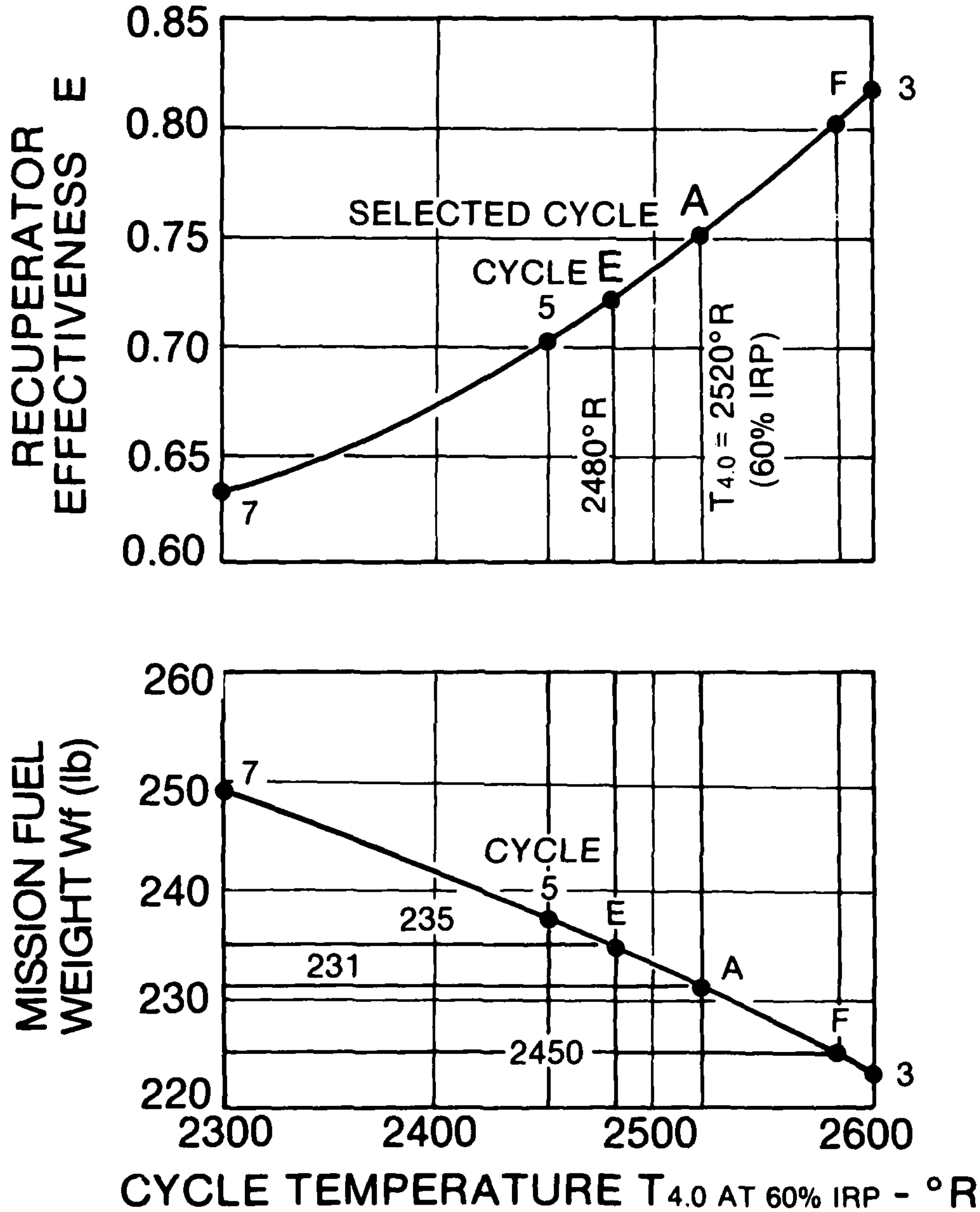


Figure 37. Interpolation of candidate cycles A, E and F

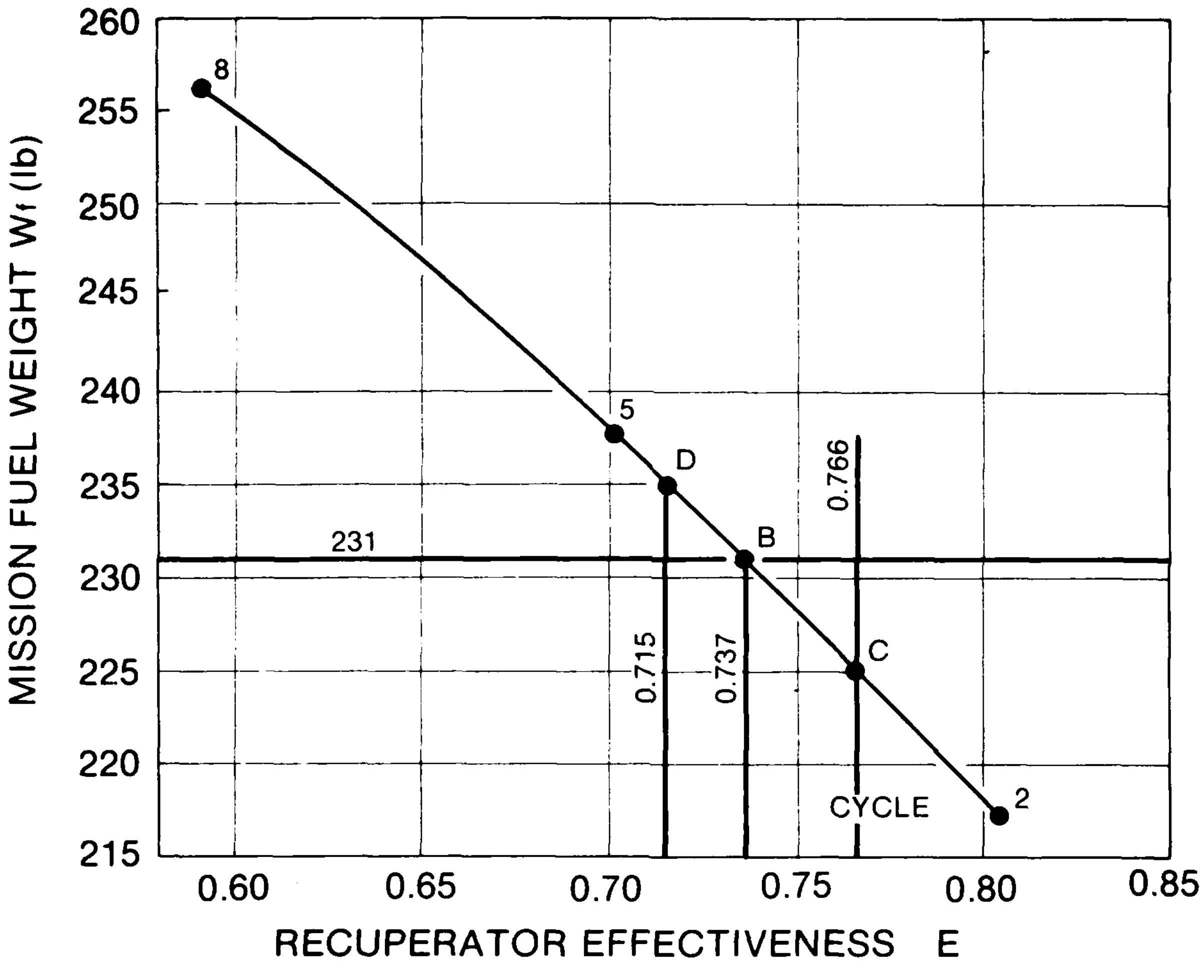


Figure 38. Interpolation of candidate cycles B, C and D

E and F lie on a line joining cycle points 3, 5, and 7, i.e., a line of decreasing cycle temperature and effectiveness. Cycles B, C, and D lie on a line joining points 2, 5 and 8, i.e., a line of constant $T_{4.0}$ and decreasing E, on which point B defines a cycle with W_f = 231 pounds equivalent to A. Cycle A is favored because of the lower engine + mission fuel weight. Cycles D and E with essentially equivalent W_{e+f} both have higher mission fuel weights W_f than A. Finally, the curve W_f = 231 pounds has a minimum slightly to the right of point A, showing that Cycle A achieves the desired compromise with minimum cycle temperature. Cycle A with the following 60% IRP characteristics

$$T_{4.0} = 2520^{\circ}R, \quad PR = 7.4 \text{ (Figure 26)}, \quad E = 0.75$$

thus has been selected for final recuperator design and cycle analysis.

Figures 39-41 show the performance characteristics of the tubular recuperator and the selected final design data, i.e., E = .76, $\Sigma \Delta P/P$=3% (60% IRP), ID = 16.5 inches, OD = 23.5 inches, core length L = 10.0 inches, tube diameter D = .15 inch, dimple factor $\mathcal{E}/D$ = .105, core weight W_c = 35/53 pounds for .004/.006-inch tube thickness and 2750 U-tubes. Figure 42 shows the recuperator performance characteristics over the entire operating range. Detailed cycle and recuperator design and off-design data are listed in Appendices C and D.

Figure 43 shows the final compressor operating line. Figure 44 shows the engine SFC over the entire operating range, together with the mission fuel weight W_f.

With the IRP cycle data:

W_a = 3.1909 lb/sec, PR = 10.809, $T_{4.0} = 2750^{\circ}R$, Equation (8) yields W_{e-r} = 135.9 lb.

Recuperator core weight is 35 lb, wrap-up weight 42.3 lb, and total engine weight W_e = 213.2 lb.

Engine + mission fuel weight is W_{e+f} = 213.2 + 229.5 = 442.7 lb.

Engine Acquisition cost $C_{a_{e-r}}$ is calculated with equation (15):

$$C_{a_{e-r}} = 30.5 \cdot 3.1909 \left[1 + 0.00967\,(10.809-7.930)\right]$$
$$\times \left[1 + 0.06601\,(2750/2200-1)^{0.5}\right]\left[1 + 0.1081\,(2750/2200-1)^{0.5}\right]$$
$$= \$108{,}918.00$$

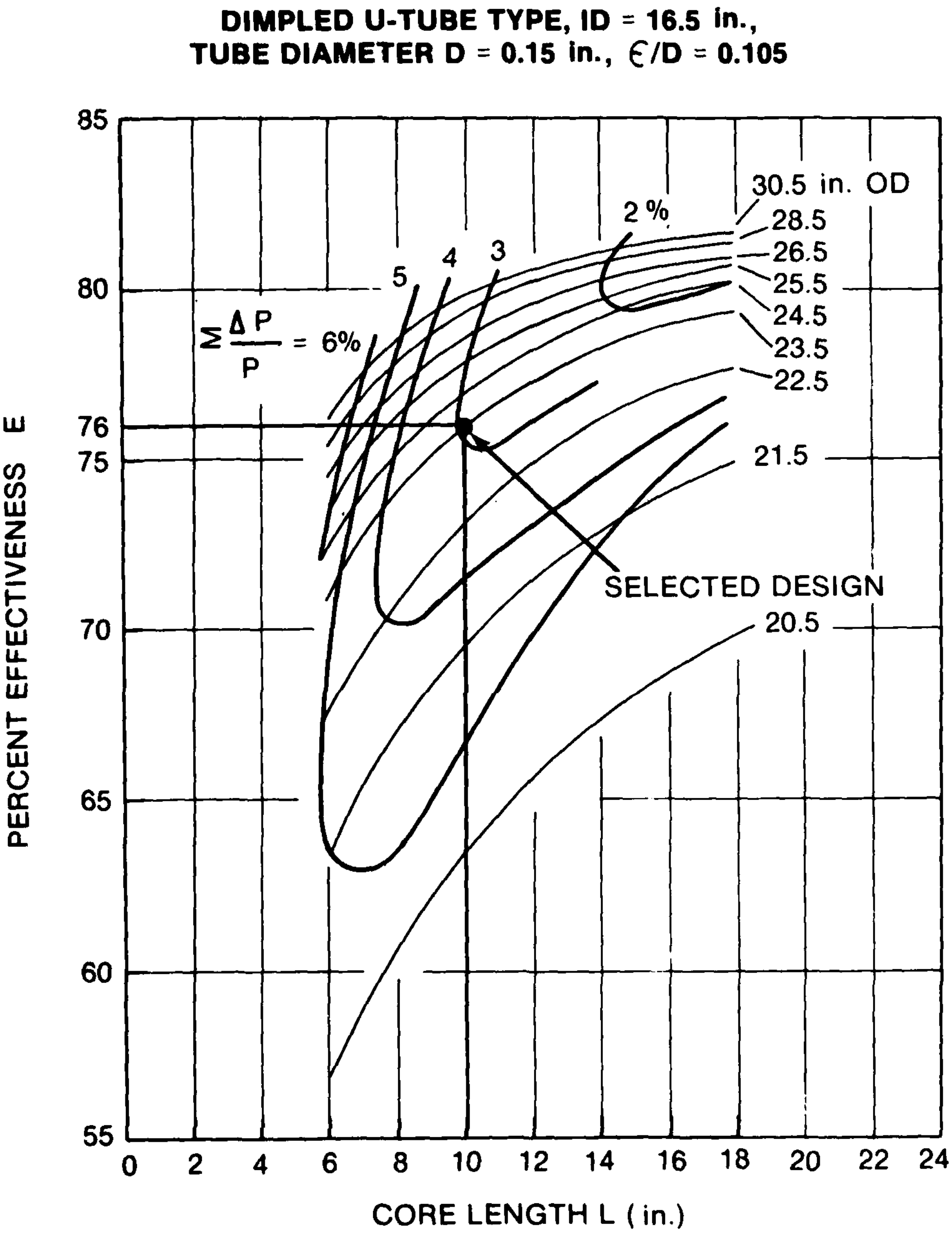


Figure 39. Tubular recuperator performance map, selected cycle

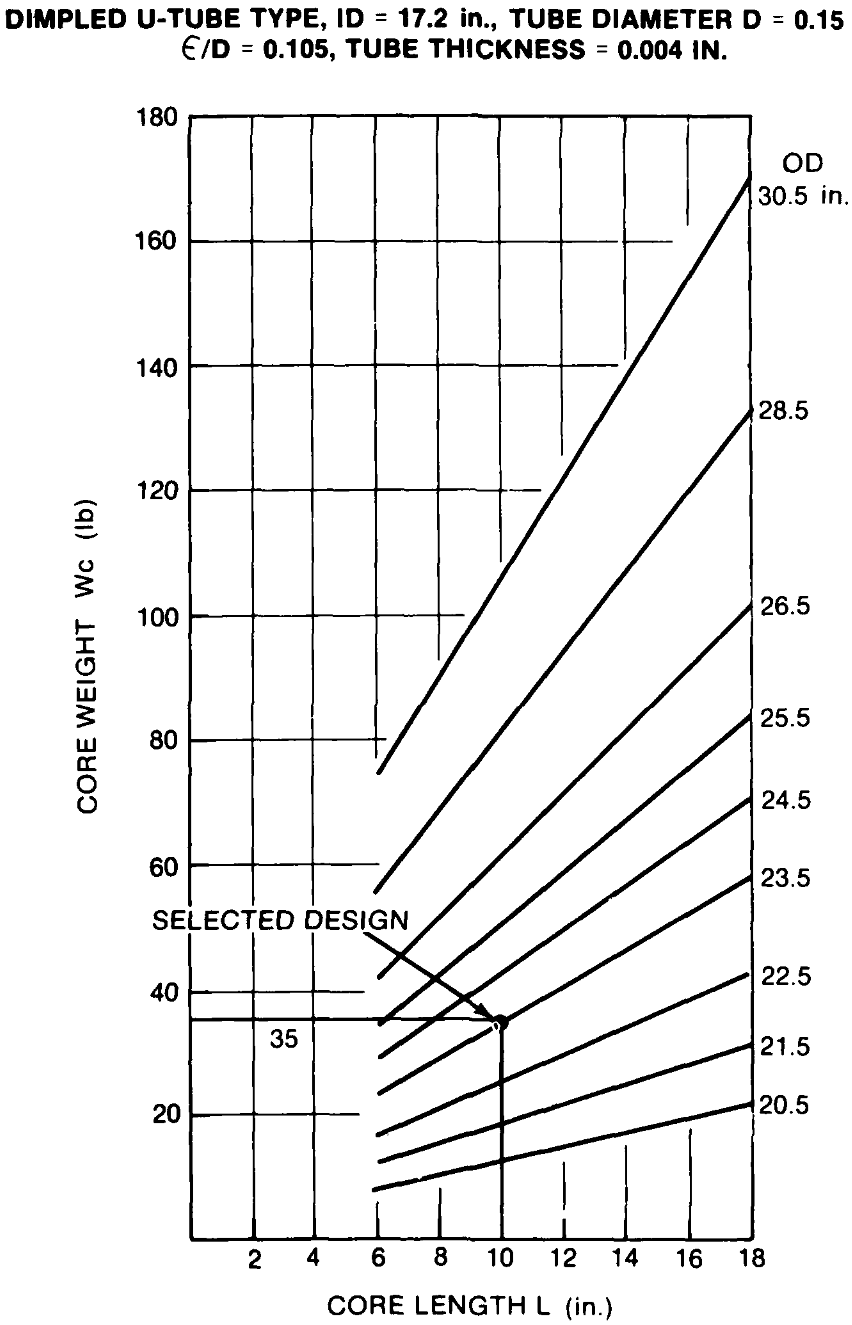


Figure 40. Tubular core weight, selected recuperator

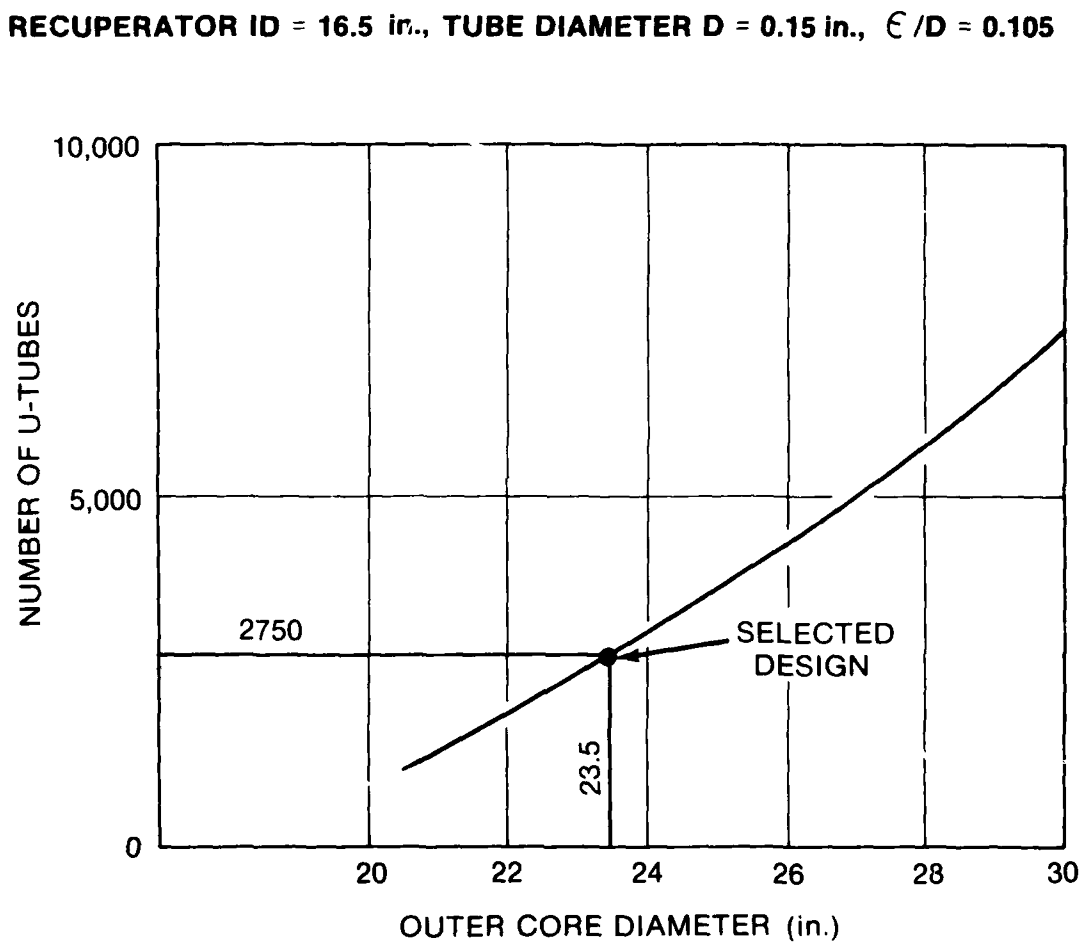


Figure 41. U-tube number, selected recuperator

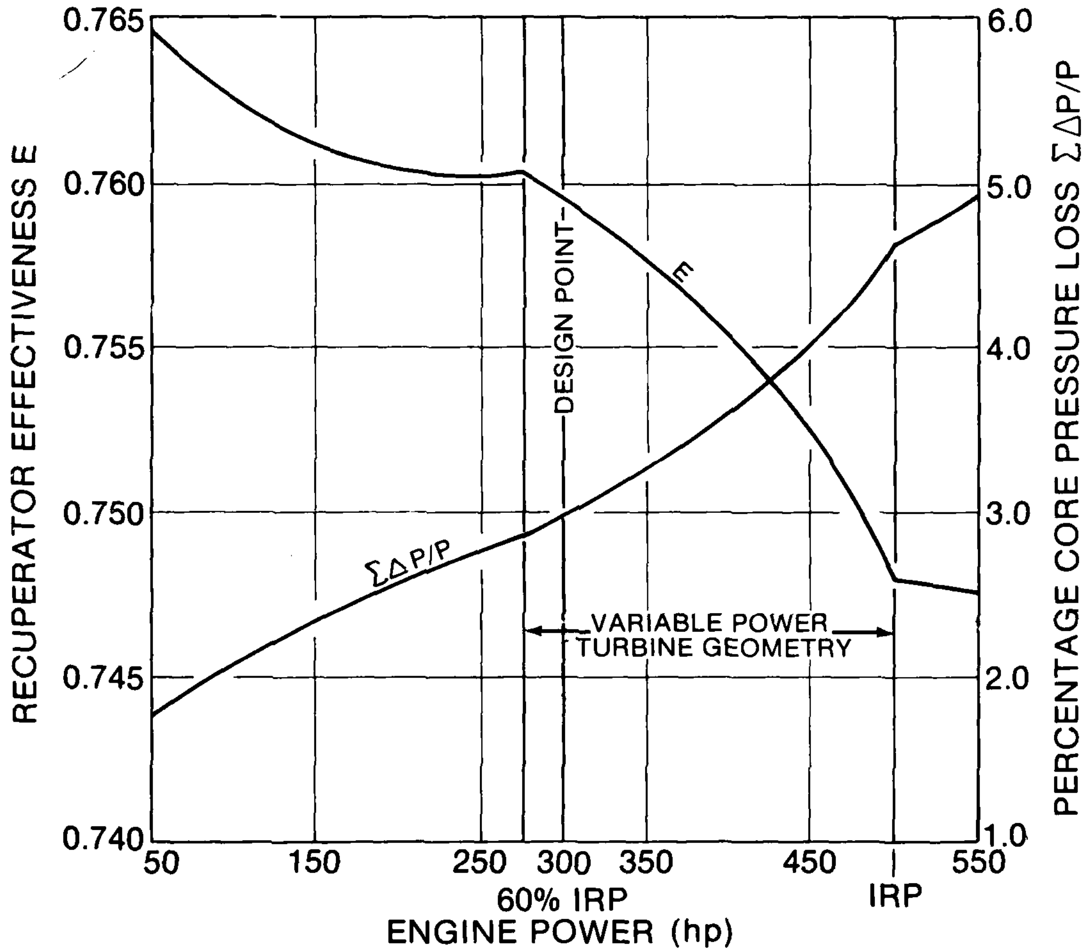


Figure 42. Off-design effectiveness and total pressure loss for selected tubular recuperator

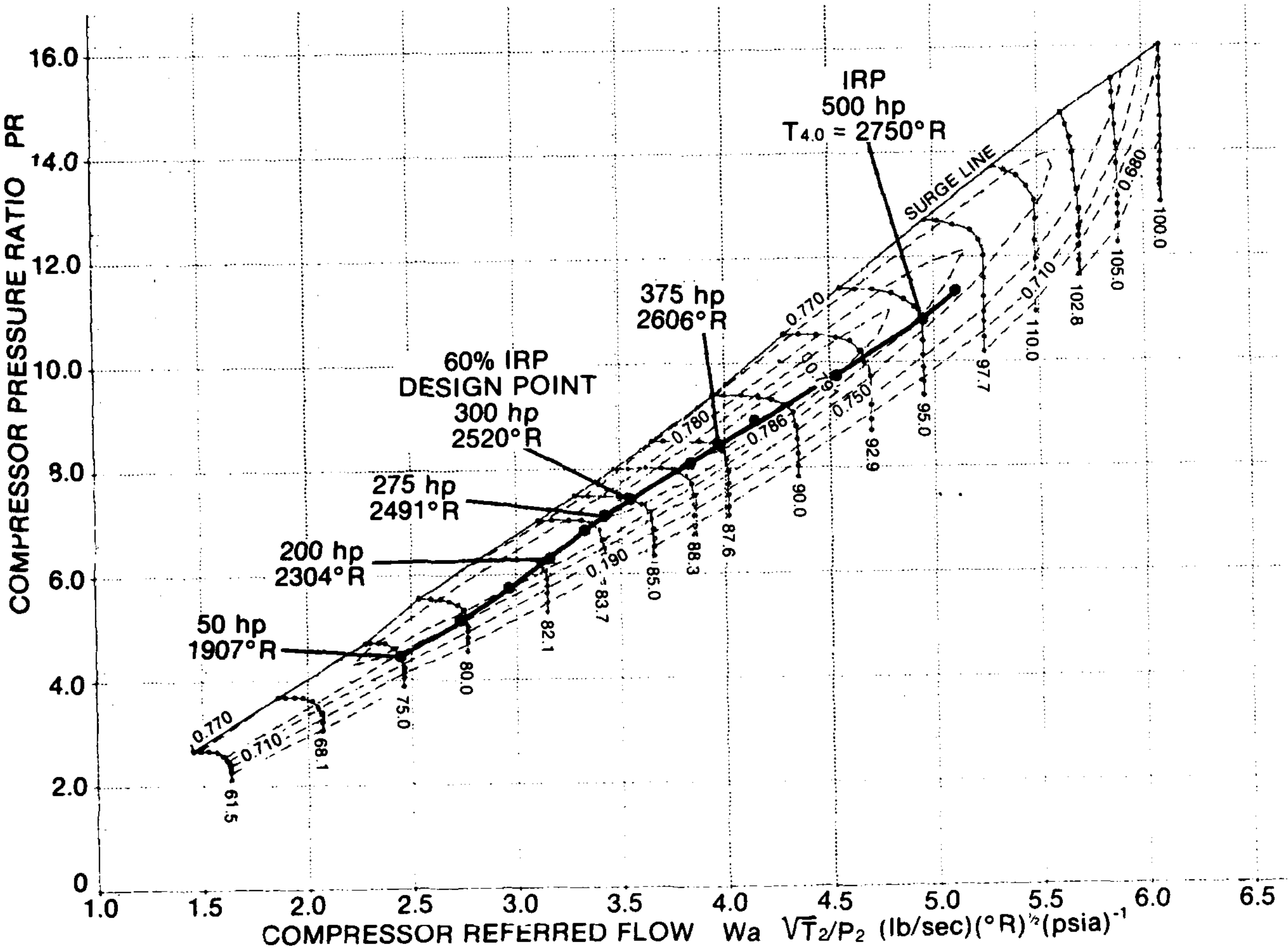
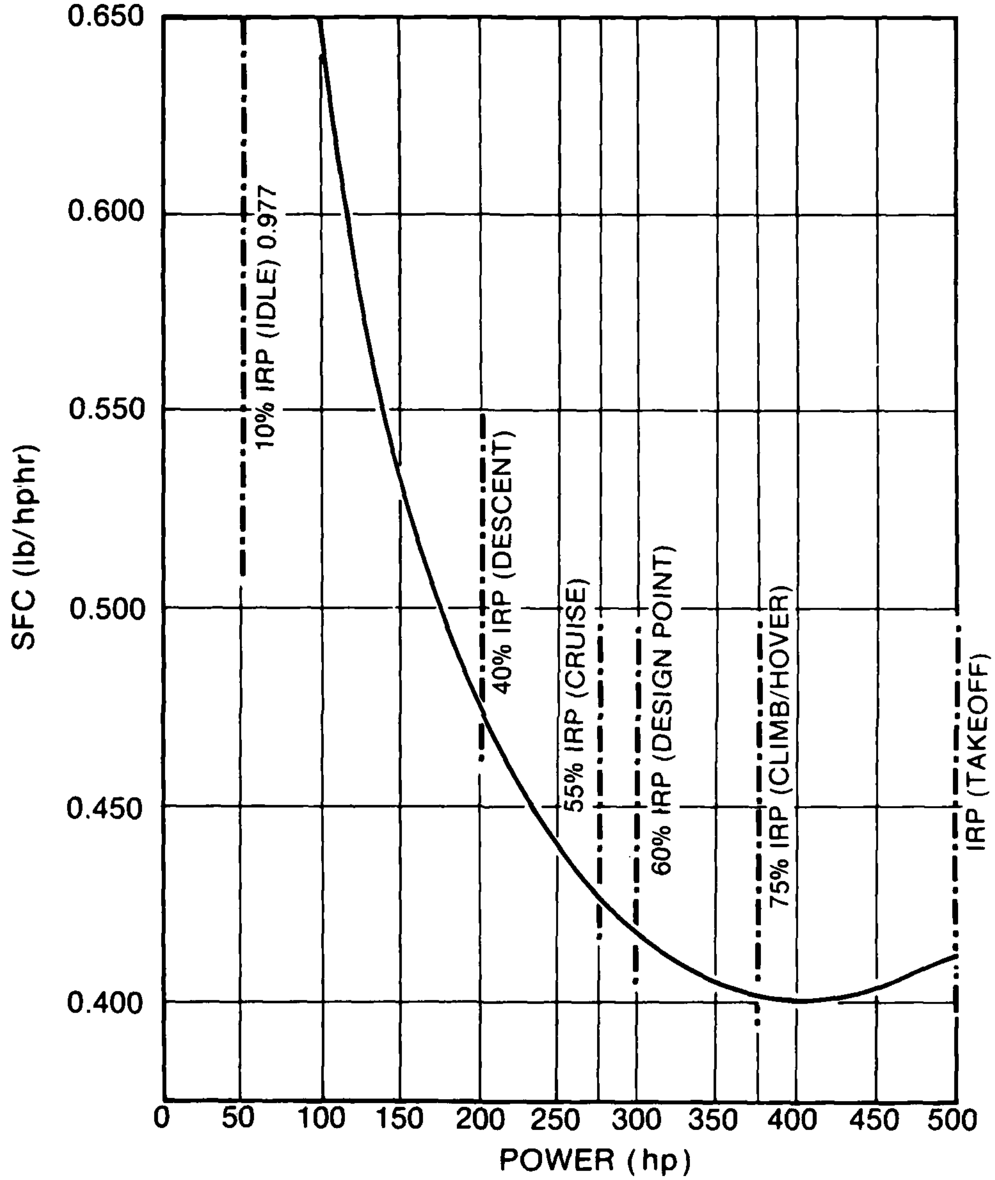


Figure 43. Operating line, selected cycle



MISSION FUEL =

14.65 +	28.32 +	105.65 +	60.21 +	20.61	= 229.5 lb
IDLE	DESCENT	CRUISE	C/H	T-0	
6.4%	12.3%	46.0%	26.2%	9.0%	

Figure 44. Selected Engine SFC (uninstalled)

Recuperator acquisition cost according to Engine Acquisition Cost is:

Materials	3174 · 35/22	=	\$ 5,050.00
Labor	21686 · 2750/2520	=	\$ 23,666.00
Recuperator acquisition cost C_{a_r}		=	\$ 28,716.00
and the total engine acquisition cost is C_{a_e}		=	\$137,634.00

The main characteristics of the selected engine are summarized as follows:

Cycle Data:

60% IRP (300 hp): $T_{4.0} = 2520^\circ R$, PR = 7.4,
$W_a = 2.289$ lb/sec, E = .76.

IRP (500 hp): $T_{4.0} = 2750^\circ R$, PR = 10.81
$W_a = 3.191$ lb/sec, E = .75.

Weights:

Turbomachinery W_{e-r}	=	135.9 lb
Tubular recuperator W_r	=	77.3 lb
Engine W_e	=	213.2 lb

Acquisition cost, 100th Engine (1979 dollars)

Turbomachinery $C_{a_{e-r}}$	=	\$108,918.00
Tubular recuperator C_{a_r}	=	\$ 28,716.00
Engine C_{a_e}	=	\$137,634.00

The above weights and costs are reevaluated in ENGINE WEIGHT and ENGINE COST on the basis of the engine preliminary design.

Waveplate and Tubular Recuperator Weight Comparison

The waveplate recuperator has been sized for the final cycle. Figure 45 shows the performance map and core weight for $\Sigma \Delta P/P = 3.0\%$ and E = .76 at 60% IRP, i.e., recuperator performance data equivalent to those of the selected tubular design. The maps yield a diameter OD=24.8 inches, a core length L = 8.15 inches, and a core weight W_c = 96 pounds (Point A). Essentially equivalent cycle performance can be obtained with the following set of design parameters:

E = .75,	$\Sigma \Delta P/P$ = 2.5%,	OD = 24.1 inches,	L = 9.2 (Point B)
.77	3.5	25.5	7.3 (Point C)
.78	4.0	26.2	6.8 (Point D)

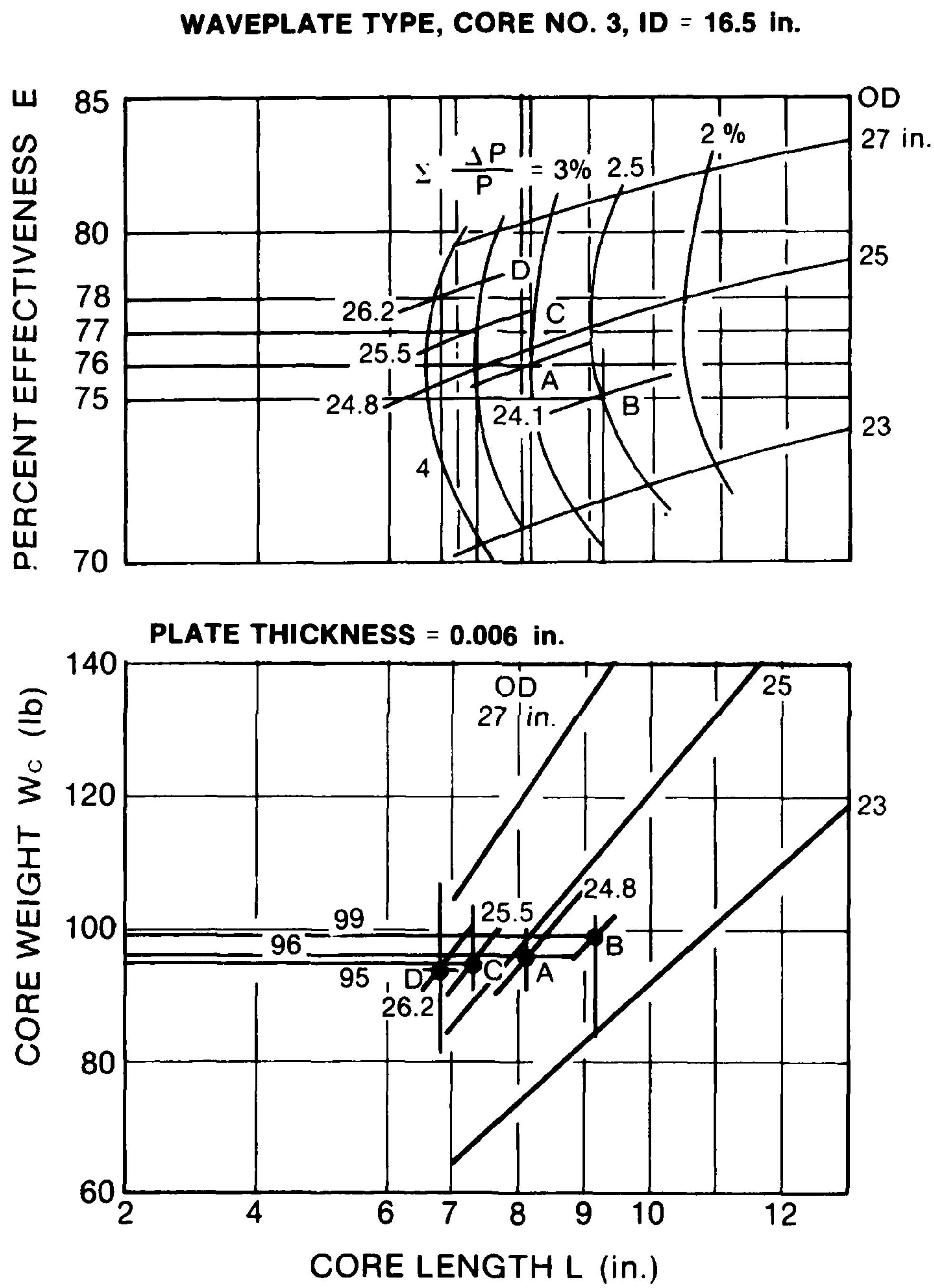


Figure 45. Waveplate recuperator performance map and core weight

yielding core weights of 99, 95 and 94.5 pounds, respectively.

Wrap-up weight is substantially influenced by the design of the core end plates that maintain the waveplates under compression to prevent cross-flow leakage. Assuming end plates of .08-inch thickness reinforced by ribs and tied by four 1/4-inch bolts, a wrap-up weight of 42.5 pounds is calculated; thus W_r= 94.5 + 137.0 pounds. Table 10 compares the weights of the engine with tubular and waveplate recuperators.

TABLE 10. COMPARISON OF ENGINES WITH WAVEPLATE AND TUBULAR RECUPERATORS

All weights in pounds.

Recuperator Type	Core Weight	Wrap-up Weight	Recuperator Weight	Turbo-Machinery Weight	Engine Weight
Waveplate 0.006 in.	94.5	42.5	137	135	272
Tubular 0.004/0.006 in.	35/53	42	77/95	135	212/230

For identical payload and mission capability, the lighter engine with tubular recuperator yields a fuel savings that should be evaluated on the basis of a detailed helicopter mission analysis.

Comparison with Constant Power Turbine Geometry and Nonregenerative Engines

For this comparison, the regenerative cycle of the constant geometry engine has been optimized with E = .75 and $T_{4.0}$ = 2750°R at IRP. The recuperator is sized at 60% IRP with $\Sigma \Delta P/P$ = 3.0%, i.e., for the same conditions as for the selected variable geometry engine. Figure 46 shows the power turbine efficiency variation for constant rpm over the entire operating range. At the design point, the efficiency of the constant geometry turbine has been assumed 1 percentage point higher, i.e., η_{ad}= .89 vs .88, for the variable geometry case. Furthermore, the design point of the constant geometry turbine is set at 60% IRP. This is possible because the referred inlet flow remains constant from 300 to 500 hp and the referred exit flow increases by only 21%, entailing a small performance penalty for the IRP point. The same compromise cannot be made for the power turbine with variable geometry since the

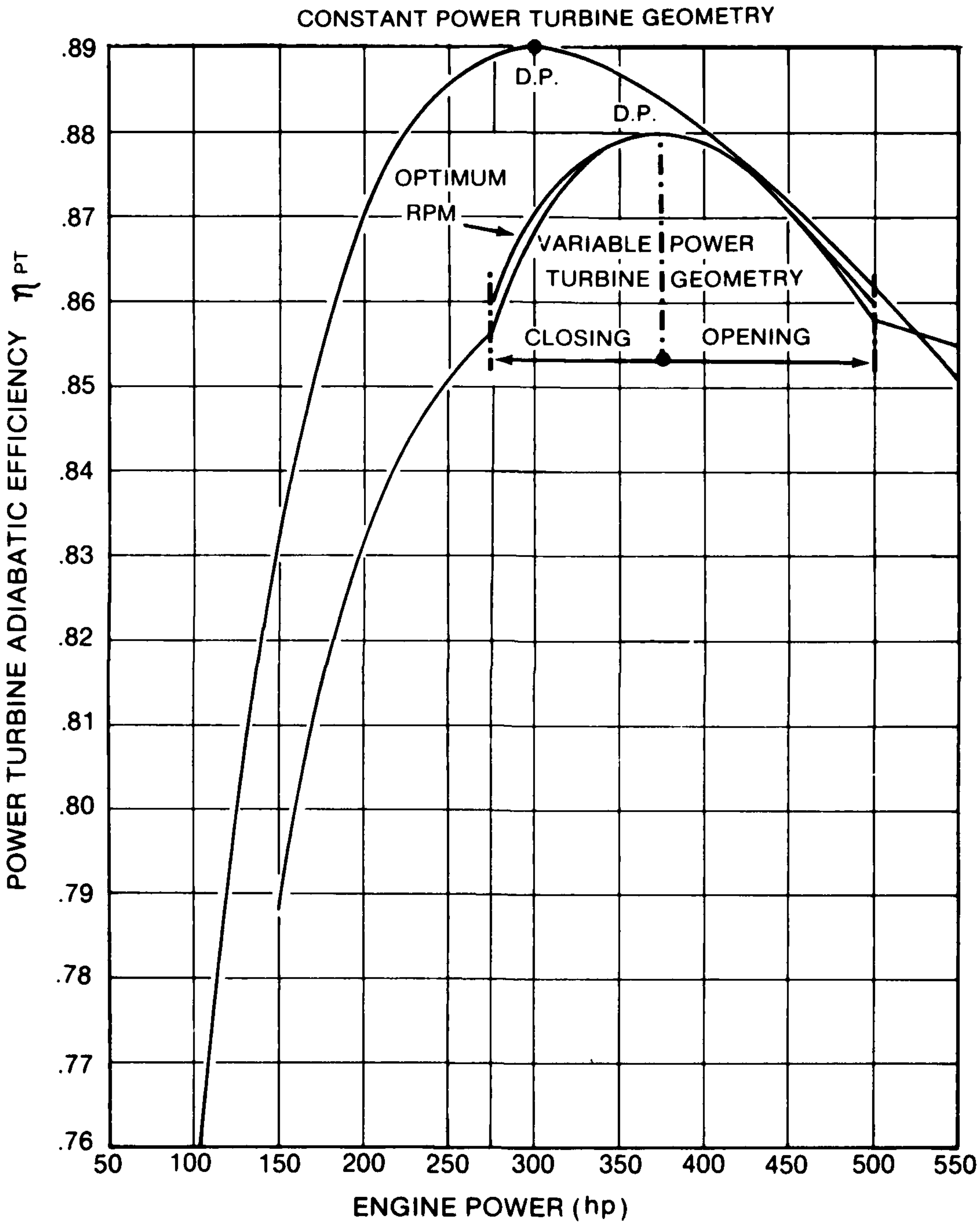


Figure 46. Power turbine efficiency characteristics

additional efficiency penalty that would result from opening the nozzle would require an undesirable cycle temperature increase at IRP, in turn requiring an increase of cooling air flow that would further penalize engine performance. For the selected 375 hp design point, the stator area increases by 13.4% at 500 hp and decreases by 5.6% at 275 hp, indicating a design compromise already strongly favoring part-power operation.

The nonregenerative cycle has been selected with equivalent $T_{4.0}$ at IRP and a pressure ratio PR = 14.0 that can be achieved by a 2A + 1C compressor.

Table 11 compares the SFC's at the various mission power points and the mission fuel weights.

TABLE 11. FUEL CONSUMPTION OF ENGINES WITH VARIABLE AND CONSTANT POWER TURBINE GEOMETRY AND WITHOUT RECUPERATOR

Power		50	200	275	375	500	Mission Fuel (lb)
Variable PT Geometry	SFC* (lb/hp-hr)	0.9883	0.4748	0.4293	0.4026	0.4120	230.6
Constant PT Geometry	SFC*	1.0434	0.5071	0.4544	0.4215	0.4015	241.8
Nonregenerative Engine	SFC	1.3158	0.5855	0.5248	0.4865	0.4651	281.0

* E = 0.75 = constant

Table 12 compares the various weights and the acquisition costs of the three engines.

For the variable vs constant power turbine geometry engine, the mission fuel savings for equivalent helicopter gross weight are 11.2 pounds, i.e., 28,000 pounds for a 5000-hour mission life and $4,200.00 at a conservative cost of $ .15 per pound. Those savings are higher for equivalent payload and mission capability. The savings are based on the power turbine efficiency characteristics shown on Figure 46 which

TABLE 12. COMPARISON OF ENGINE WEIGHTS AND ACQUISITION COSTS

Engine Type	60% IRP		IRP		Mission Fuel Weight W_f (lb)	Recuperator Weight W_r (lb)	Engine Weight W_e (lb)	Engine + Mission Fuel Weight W_{e+f} (lb)	Acquisition Cost C_a ($)
	$T_{4.0}$ (°R)	PR	$T_{4.0}$ (°R)	PR					
Variable PT Geometry	2520	7.40	2750	10.81	230.6*	77.3	213.2	443.8	139,936
Constant PT Geometry	2322	6.50	2750	8.20	241.8*	96.8	229.5	471.3	149,274
Nonregenerative Engine	2374	10.91	2750	14.00	281.0	--	127.1	408.1	84,852

*E = 0.75 = Const.

require careful design of the variable stator assembly to minimize the additional blading mismatch and clearance losses.

For the recuperative vs the nonregenerative engine, the mission fuel savings for equivalent gross weight are 50.4 pounds, i.e., 126,000 pounds for the mission life and $18,900.00, while the additional acquisition cost of the recuperative engine is $55,084.00, leaving an engine acquisition + mission life fuel cost differential of $36,184.00 in favor of the nonregenerative engine.

The above savings are reevaluated on the basis of the preliminary engine design.

POTENTIAL IMPROVEMENTS OF THE REGENERATIVE ENGINE

Table 1 indicates the SFC improvement that can be achieved through components efficiency improvements. For an optimum cycle with .75 recuperator effectiveness, 2400-2600°R 60% IRP temperature and .84 polytropic efficiency index, a 1 percentage point increase of the compressor and turbine sections efficiencies yields an SFC improvement of roughly 3%. The development of rotor tip clearance control offers the most promising means to improve components efficiency for small gas turbines. As a result, the polytropic efficiency index can be expected to increase from .84 to .86 during the next decade, yielding a 6% improvement of the regenerative engine SFC.

Improvements of turbomachinery components obviously benefit the conventional as well as the regenerative cycle and do not substantially alter their performance comparison. The performance of the regenerative engine, however, is affected by two inherent penalties:

(a) Recuperator pressure losses

(b) Cooling air bypassing the recuperator

Reducing those penalties results in an intrinsic performance improvement of the regenerative cycle.

Recuperator pressure loss can be minimized only at the cost of additional weight. For the selected cycle, the total recuperator pressure loss of 3% constitutes a favorable compromise between weight and SFC. The second penalty could be eliminated by introducing turbine hardware that needs no cooling. Ceramics offer the most promising solution of the problem.

For the foreseeable future, cooling air quantities can be minimized by:

(a) Using a ceramic gas producer nozzle and improved heat resistant materials, among which single-crystal alloys with MCrAlY coating presently offers the best potential improvement over C101 and C103.

(b) Improving the part-speed compressor surge margin

(c) Bypassing the recuperator gas side at the higher engine ratings.

CERAMIC TURBINE AND IMPROVED MATERIALS

Figure 47 shows the SFC improvements achievable for Cycles 4,5, and 6 (60% IRP $T_{4.0}$ = 2300, 2450, 2600°R and E=.7) by introducing uncooled ceramic gas producer nozzle and rotor components. The effect of the ceramic nozzle is to shift minimum SFC from $T_{4.0}$= 2350 toward 2500°R, i.e., to the temperature level selected as compromise between minimum SFC and minimum engine+mission fuel weight for the proposed engine.

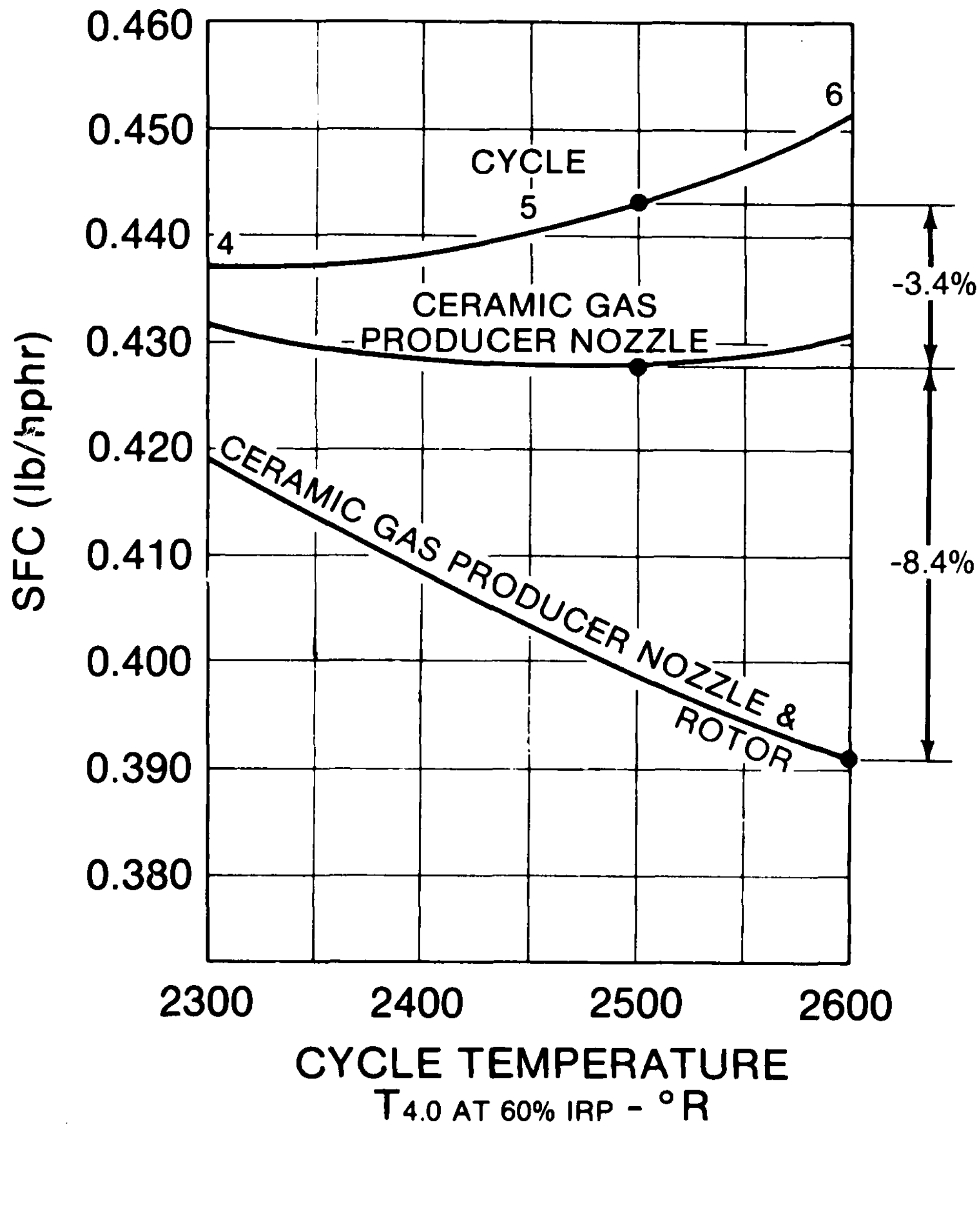


Figure 47. Potential SFC improvements through ceramic turbine components

The SFC gain at that temperature is approximately 3.4%. Adding a ceramic rotor reverses the SFC-temperature trend, and an additional 8.4% or a total 11.8% SFC gain can be achieved by going to $T_{4.0}$ = 2600°R at IRP.

The introduction of a ceramic gas producer nozzle can be confidently considered within a 5-10-year development period. A ceramic gas producer turbine rotor is not considered practically feasible within the next decade. From Figure 47, introducing improved heat resistant materials for the rotor in addition to the ceramic nozzle can be expected to yield an additional 3-5% SFC improvement.

The ceramic nozzle reduces the mission fuel consumption of the selected regenerative engine by 5.2% to 218.7 pounds, the engine weight to 204.2 pounds, and the acquisition cost to $131,723.00. For the nonregenerative engine, the ceramic nozzle reduces the mission fuel consumption by 1.7% only, i.e., to 276.2 pounds, the engine weight to 120.3 pounds, and the acquisition cost to $80,286.00. On the basis of equivalent gross weight, the mission fuel savings for the recuperative engine are 57.5 pounds, i.e., 143,750 pounds for the 5,000-hour mission life, and $21,562.00, while the additional cost of the regenerative engine is $51,437.00. The cost differential in favor of the nonregenerative engine has been reduced from $36,184.00 to $29,875.00.

COMPRESSOR SURGE MARGIN INCREASE

A 10% increase of the part-speed surge pressure can be obtained by replacing the combined axial-centrifugal by a two-stage centrifugal compressor. For the basic 2A + 1C map used in this analysis, this corresponds to shifting the 60% IRP matching point to its surge line. Representative point E (Figure 2) has been selected for the 60% IRP condition with cycle data essentially equivalent to those of the proposed engine. Provided that the efficiency contours are not drastically shifted together with the surge line, the effect of the increased surge margin is to minimize the efficiency degradation toward IRP. This minimizes the IRP temperature and permits a decrease of the cooling air quantity, which in turn yields an improved SFC.

The decrease of IRP cycle temperature, however, also results in a decrease of specific power and an increase of engine weight that tends to offset the mission fuel savings. In order to assess this trade-off, two IRP temperatures have been investigated: $T_{4.0}$=2600°R, which is the lowest value achievable without running off the compressor map, and $T_{4.0}$ = 2675°R, midway between the lowest and the actual 2750°R value of the selected cycle.

Figure 48 shows the operating line obtained for the case of the lower IRP temperature level of 2600°R, assuming an engine with a ceramic gas producer turbine nozzle. The rotor cooling air has been decreased from 5.7% to 3.3%. For the case with $T_{4.0}$ = 2675°R at IRP, the cooling air is reduced to 4.4%.

Table 13 compares the calculated performance characteristics of engines fitted with a ceramic gas producer turbine nozzle. It will be seen that keeping the lowest possible cycle temperature increase toward IRP penalizes engine specific power to the extent that the mission fuel savings are more than offset by the increase of engine weight. By allowing the IRP cycle temperature to increase to 2675°R, the engine with a 2C compressor configuration achieves an engine + mission fuel weight W_{e+f} that is equivalent to that of the proposed engine with a 2A + 1C design and a slight advantage in mission life fuel savings. The additional benefit of a 75°R decrease of the IRP cycle temperature is not considered significant for the comparatively moderate turbine inlet temperature level considered in this study.

The higher part-speed surge margin achievable with a 2C compressor thus cannot be used to substantially improve the overall economy of a regenerative engine configured with a combined axial-centrifugal compressor.

RECUPERATOR BYPASS

Bypassing the recuperator gas side at the higher power ratings eliminates the gas side pressure loss and permits an IRP temperature decrease without specific power loss. This trade-off is materialized for a temperature decrease of 50°R, i.e., $T_{4.0}$ = 2700°R at IRP, which enables a reduction of the rotor cooling air quantity from 5.7% to 4.8%. With this minor improvement, the performance calculation shows no reduction of the mission fuel consumption, the higher IRP consumption without regenerator offsetting the part-power gain for the assumed mission.

An improvement might be achieved if bypassing were used to design a smaller recuperator, trading off the resulting engine weight savings and the SFC penalty due to the higher recuperator pressure losses. Such a trade-off, however, has not been investigated in this study.

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REGENERATIVE ENGINE ANALYSIS PROGRAM.(U)

JAN 81 P SCHWAAR, J DALE, J BANKS DAAK51-79-C-0056

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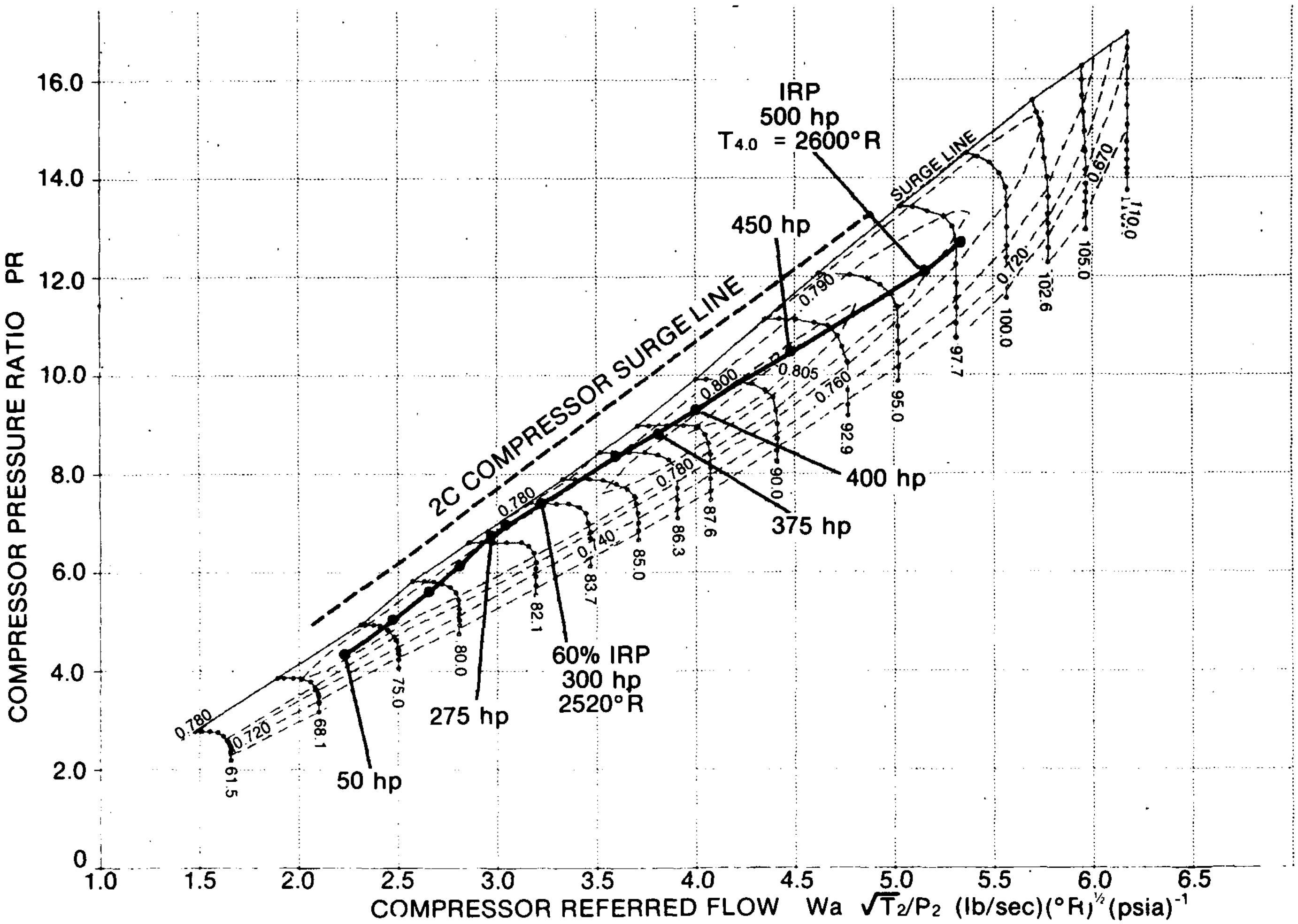


Figure 48. Operating line for a 2C compressor with increased surge margin

TABLE 13. COMPARISON OF VARIOUS ENGINE TYPES

(All Engines Fitted with a Ceramic Gas Producer Turbine Nozzle)

Engine Type	60% IRP			IRP			Mission Fuel Weight W_f (lb)	Engine Weight W_e (lb)	Σ W_{e+f} (lb)	Mission Life Fuel Savings	
	PR	$T_{4.0}$ (^oR)	W_a (lb/sec)	PR	$T_{4.0}$ (^oR)	W_a (lb/sec)				W_f** (lb)	$***
Nonregen-erative	10.88	2371	2.304	14.00	2750	2.742	276.2	120.3	396.5	-	-
2A + 1C* Selected Recuperative Cycle	7.40	2520	2.173	10.44	2750	2.929	218.7	204.2	422.9	143,750	21,562
2C* Lower IRP $T_{4.0}$	7.40	2520	2.076	12.10	2600	3.331	215.0	217.0	432.0	153,000	22,950
2C* Middle IRP $T_{4.0}$	7.40	2520	2.117	11.08	2675	3.067	216.8	206.1	422.9	148,500	22,275

* E = 0.75 = Const.
** Fixed helicopter gross weight
*** At $1.00/gal.

LIFE-CYCLE COST ASSESSMENT

A preliminary life-cycle cost assessment has been undertaken to ensure that the fuel economy achievable with the selected cycle is not offset by prohibitive overall operating cost penalties. Only engine development, acquisition, and maintenance costs have been considered in addition to mission life fuel cost. Those costs have been calculated in 1979 dollars and with a fuel cost of $1.00 per gallon. Table 14 lists the various cost items for Cycles 2-9 retained in the refined parametric analysis and for the selected engine without ceramic nozzle.

Engine life-cycle cost remains practically constant over the 0.6-0.75 recuperator effectiveness range. It increases substantially at higher effectiveness levels essentially as a result of sharply increasing recuperator acquisition cost.

The selected cycle thus achieves an optimum engine performance and life-cycle cost compromise.

TABLE 14. ENGINE LIFE-CYCLE COST (LCC) COMPARISON

$$LCC = C_d + C_a + C_m + C_f$$

Cycle Characteristics at IRP				COST (1979 K$)					
Cycle	PR	$T_{4.0}$ (°R)	E	Develop-ment C_d	Acquisi-tion C_a	Mainte-nance C_m	Mission Fuel C_f*	Engine Life Cycle LCC	Δ LCC
1	7.93	2480	0.800	-	-	-	-	-	-
2	9.19	2655	0.803	20.031	192.88	105.627	81.488	400.027	45.922
3	10.40	2835	0.813	26.473	178.789	111.440	83,663	400.365	45.260
4	9.90	2500	0.682	16.388	145.729	104.044	88.313	354.474	-0.631
5	11.19	2675	0.683	20.784	138.934	106.062	89.138	354.918	-0.187
6	12.33	2845	0.672	27.008	131.642	111.889	91.388	361.927	6.822
7	10.16	2515	0.612	16.692	141.146	104.059	93.338	355.235	0.130
8	12.23	2695	0.568	21.438	130.990	106.550	96.075	355.053	-0.052
9	12.29	2850	0.592	27.144	123.480	112.117	95.063	357.804	2.699
Selected	10.81	2750	0.750	23.245	137.634	108.163	86.063	355.105	0.0

*At $1.00 per gallon

PRELIMINARY MECHANICAL DESIGN

ENGINE CONFIGURATION

As many as possible of the design concepts and features of the 800 hp representative engine have been retained for the proposed engine. Figure 49 shows a photograph of the representative engine. Figure 50 shows a cross section of the proposed recuperative engine with the following main design features:

(a) Single spool 66,280 rpm gas producer with a 2A+1C compressor and a single-stage axial turbine

(b) Single can combustor with 360 degree scroll

(c) Free single-stage axial power turbine with constant 44,000 rpm and variable stator geometry

(d) Axial exit diffuser followed by partial flow path reversal into the recuperator entrance collector

(e) Cylindrical U-tube recuperator wrapped around the power turbine/diffuser section with air inside the tubes and gas flowing over the tubes in a single cross flow path

(f) Modular construction with integrated inlet particle separator and oil system.

Compressor

The inlet particle separator and the compressor are scaled-down designs of the representative 800 hp engine. Based on the uninstalled data of the selected cycle, the scale factor of the compressor section is determined by the referred flows $W_a\sqrt{\theta}/\delta$ of the proposed and the representative engines at the corresponding 95% of design speed. This yields a rotational speed of the proposed engine gas producer N = 66,280 rpm.

Because of the comparatively large blade chords of the representative compressor, the axial and the radial dimensions are scaled down in the same proportion.

Turbine Section

The turbine section is new and the flow path has been optimized for

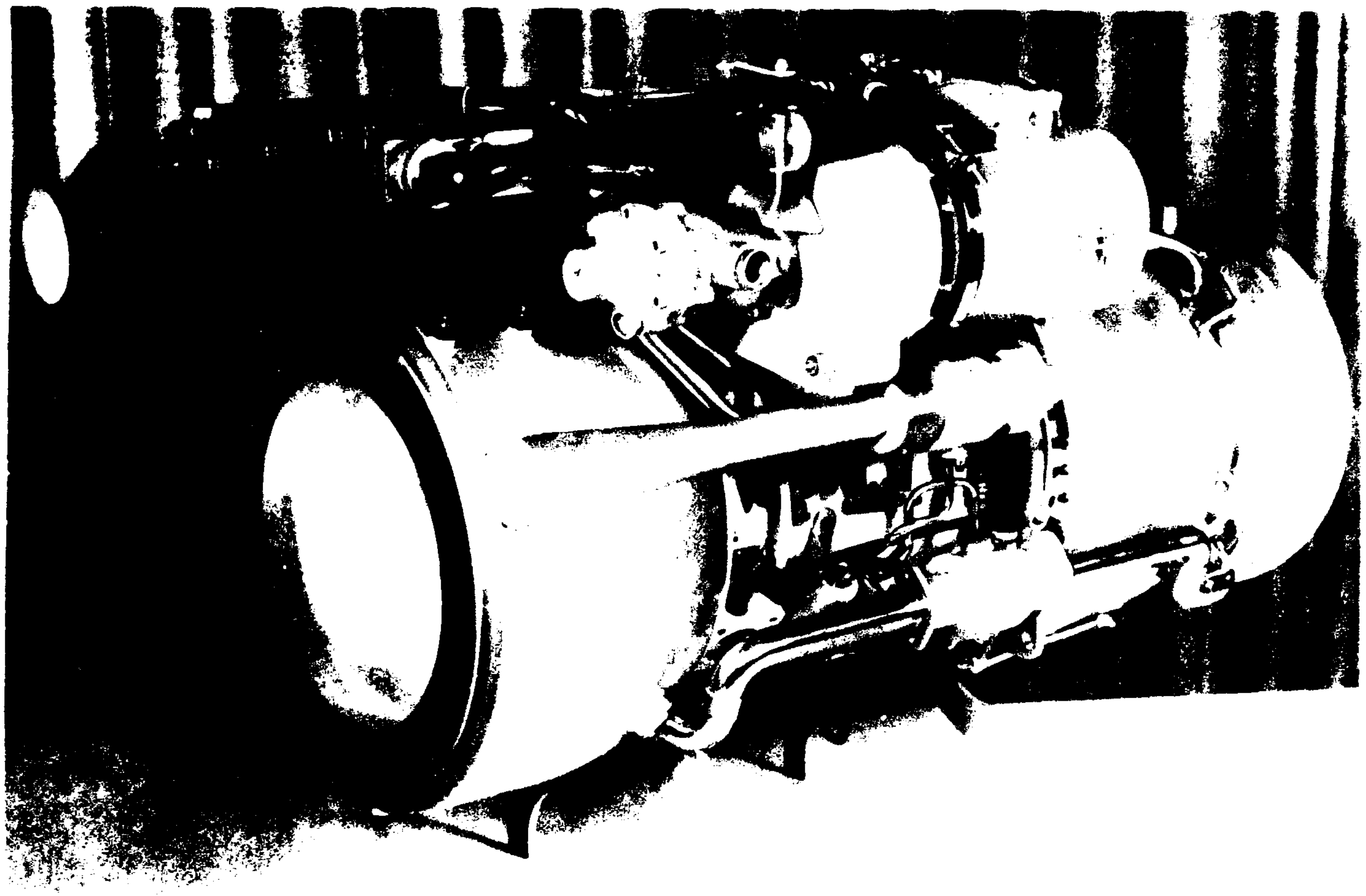


Figure 49. 800 hp representative engine cross section

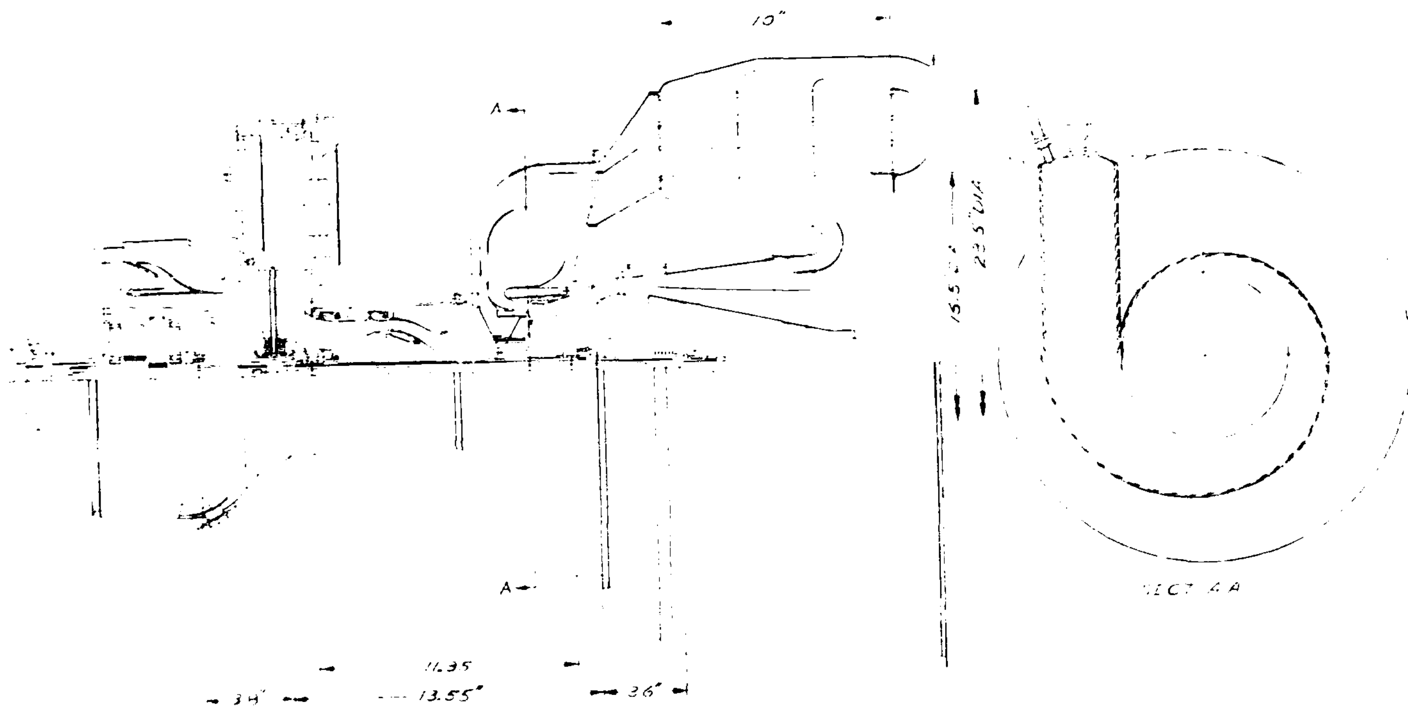


Figure 50. Recuperative engine cross section

single-stage gas producer and power turbines with minimum radial transition between the two stages.

(a) Gas Producer Turbine

The gas producer turbine is designed for the IRP conditions with the following data:

$W_{4.1}$ = 3.035 lb/sec (rotor inlet)

$P_{4.0}$ = 148.8 psia (stator inlet)

$T_{4.1}$ = 2692°R

$\eta_{ad_{GPT}}$ = .863

N = 66,280 rpm

Power = 703.5 hp

A preliminary calculation showed that favorable rotor flow conditions can be obtained with forced vortex flow conditions corresponding to a constant absolute stator exit angle α_1. For the final design, a comparatively small angle ($\alpha_1 = 19°$) has been selected in order to maximize blade height and minimize the supersonic stator exit Mach level.

Channel wall cooling generates a total temperature profile with lower temperatures at the hub and the tip sections. This is used especially at the hub section to minimize blade and disk metal temperature and to maintain high material strength. The radial temperature profile shown on Figure 51 has been assumed for design analysis. Accordingly, the work output of the rotor is not constant radially but varies linearly with the total inlet temperature. Figure 52 shows the velocity triangles for the hub, 50% mass flow, and the tip sections. The turbine is designed with constant rotor tip radius which, together with the forced vortex flow $(V_u \cdot r)_{tip}$ larger than $(V_u \cdot r)_{hub}$, keeps the relative rotor exit flow conditions below the critical transonic level at the tip section (M_{W_2} = .957). The rotor hub conicity is prolonged upstream through the stator section in order to generate a meridional flow path curvature that minimizes absolute and relative hub Mach number levels at rotor entrance.

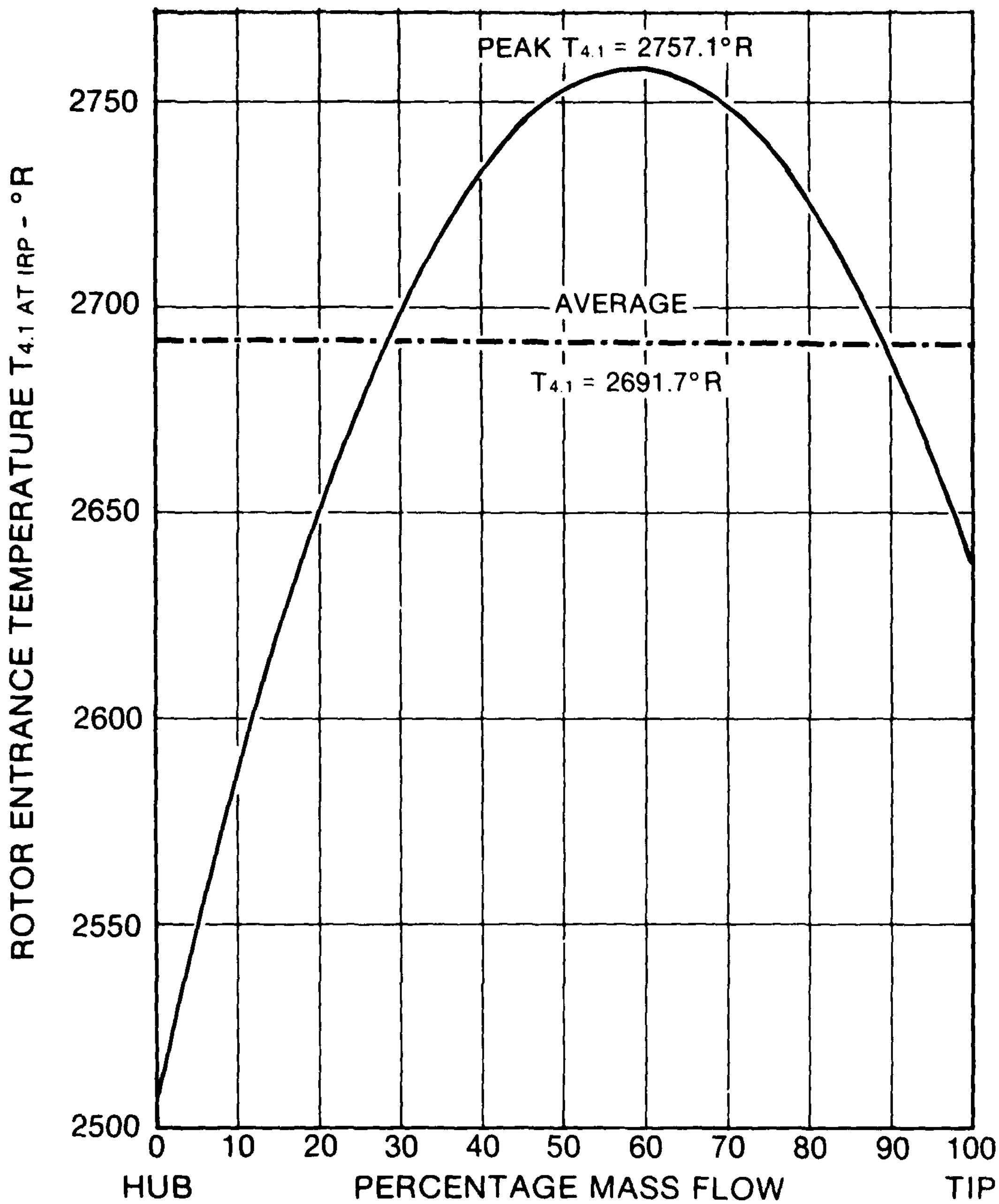


Figure 51. Assumed temperature profile at entrance of gas producer turbine rotor

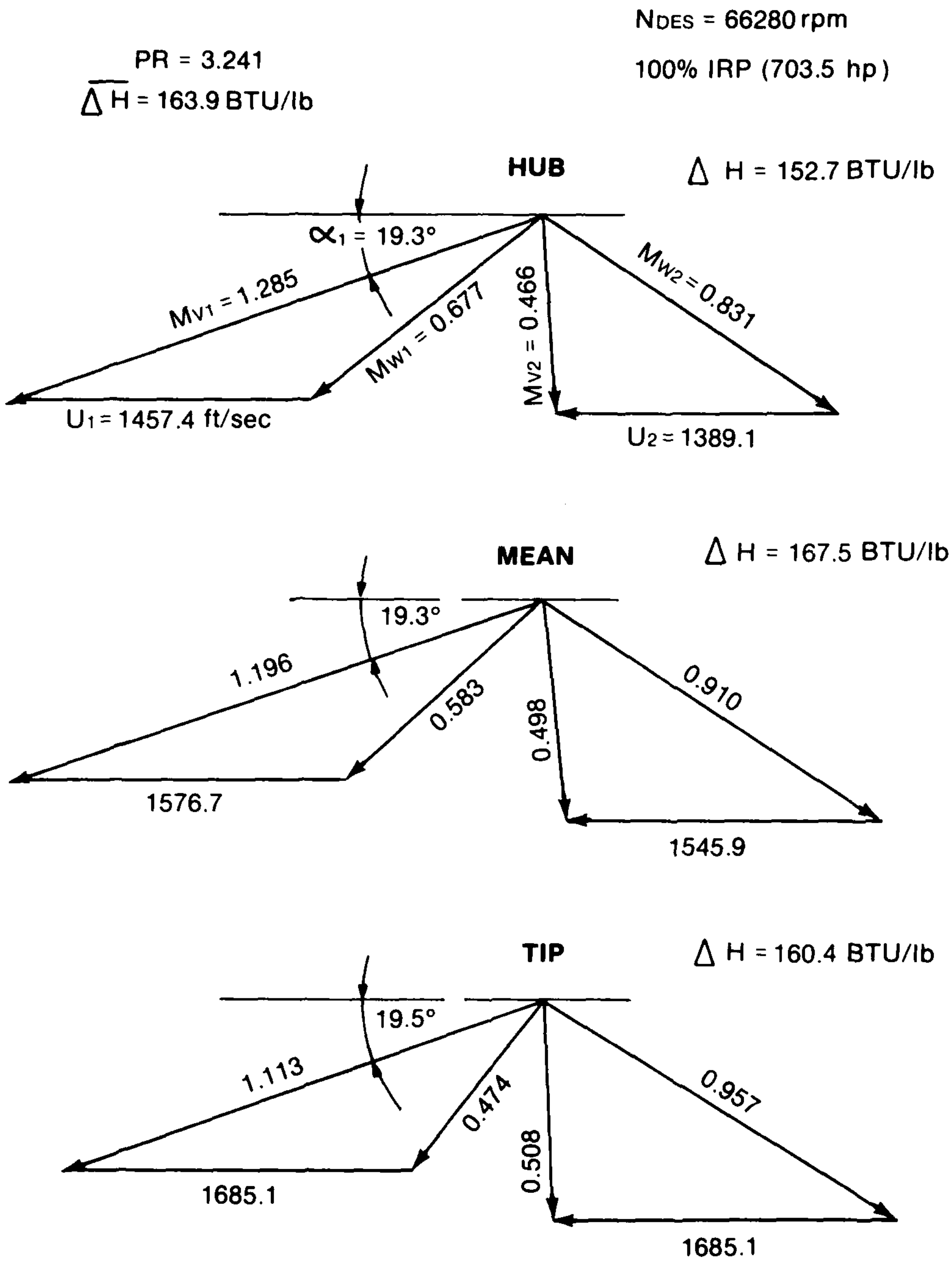


Figure 52. Velocity triangles, gas producer turbine

The turbine is designed with substantial hub reaction ($W_2/W_1 = 1.2$) and practically no exit swirl, which minimizes the losses of the transition duct to the power turbine.

The flow conditions have been calculated with a preliminary design analysis code that solves the complete radial equilibrium equation along discrete channel stations. The printout of the input and output data is attached in Appendix E. Figure 53 shows the gas producer turbine flowpath.

(b) Power Turbine

The power turbine is designed for the 75% IRP condition with the following data:

$W_{4.5} = 2.582$ lb/sec (stator inlet)

$P_{4.5} = 41.0$ psia

$T_{4.5} = 2020^{\circ}R$

$\eta\ ad_{PT} = .88$

$N = 44{,}000$ rpm

Power $= 376.9$ hp

Figure 54 shows the assumed inlet temperature profile. Figure 55 shows the design velocity triangles obtained with an average stator exit angle $\alpha_3 = 20.7^{\circ}$ and $N = 44{,}000$ rpm. Stator exit flow angle variation $\Delta\alpha_3$ is -1.2° for the 275 hp closed and $+ 2.9^{\circ}$ for the 500 hp opened stator positions. Although this variation is comparatively small, it is necessary to minimize the stator blading hub and tip clearances. This is done by providing a blading that moves between concentric spherical inner and outer walls. The clearance then remains constant for all stator setting angles. This, however, imposes an essentially constant annulus area across the stator blading, resulting in a large acceleration of the axial velocity component. Since the turbine has to be designed with minimum exit Mach level to minimize downstream diffuser losses, the transition duct between the gas producer and the power turbine in this case would have to be designed with a larger flow deceleration than otherwise necessary. The proposed compromise is to

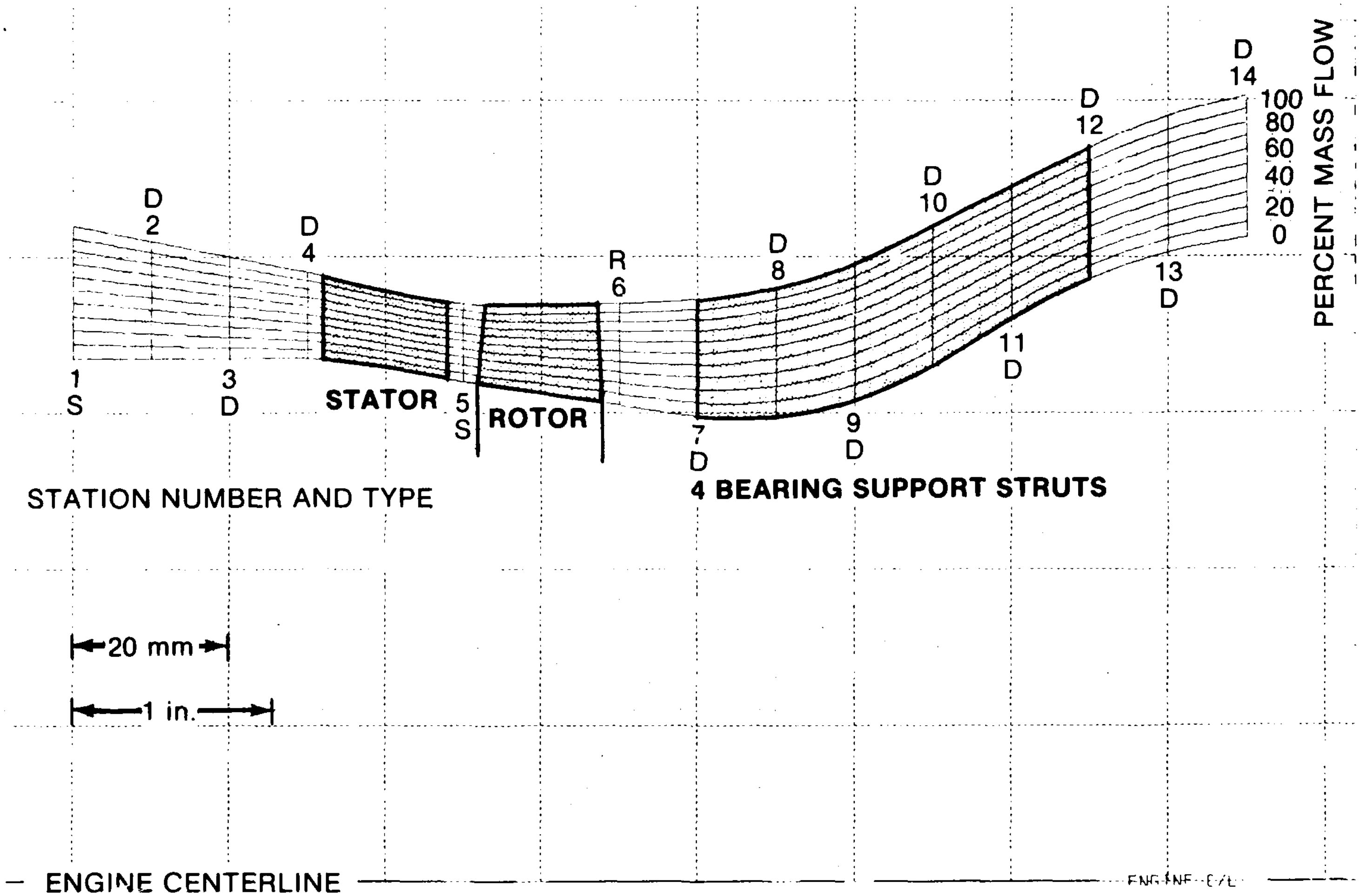


Figure 53. Meridional flowpath and streamline pattern, gas producer turbine and transition duct

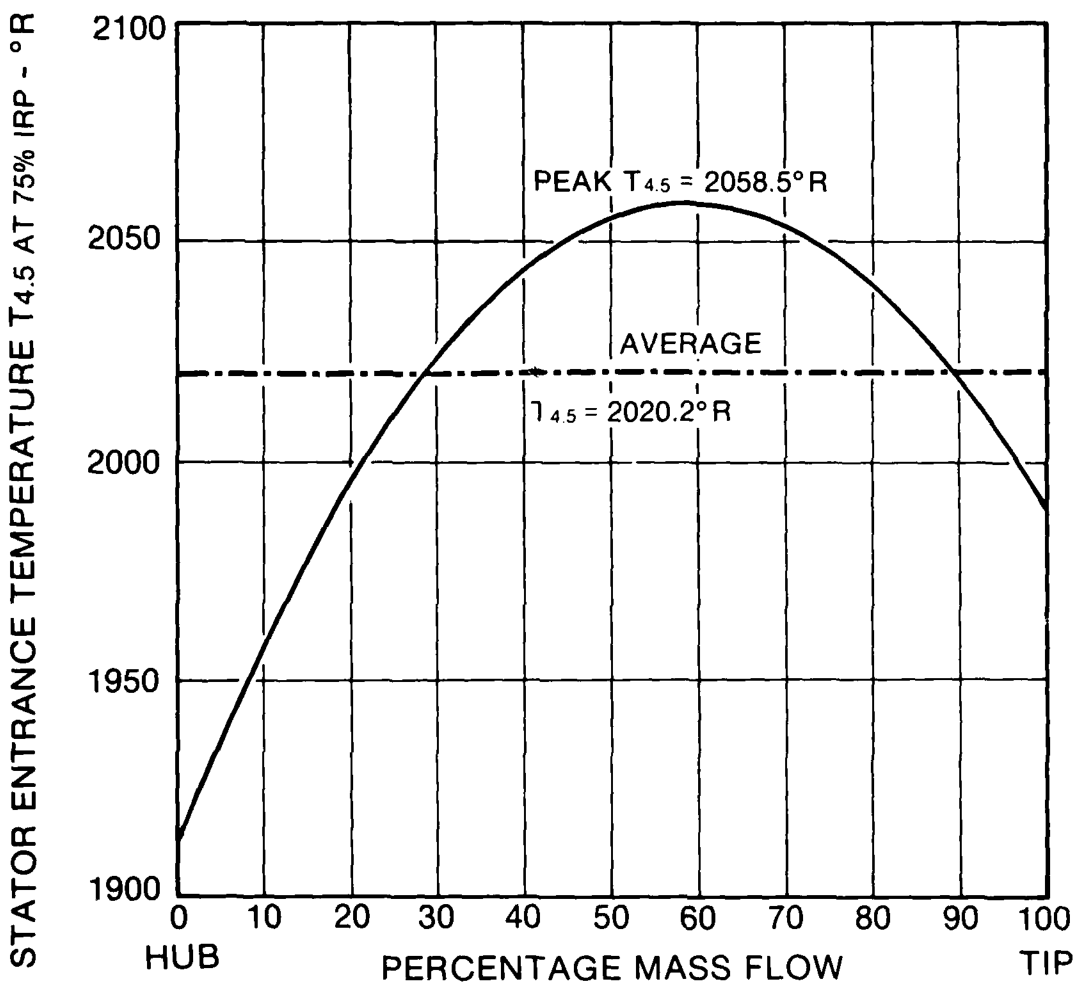


Figure 54. Assumed temperature profile at entrance of power turbine

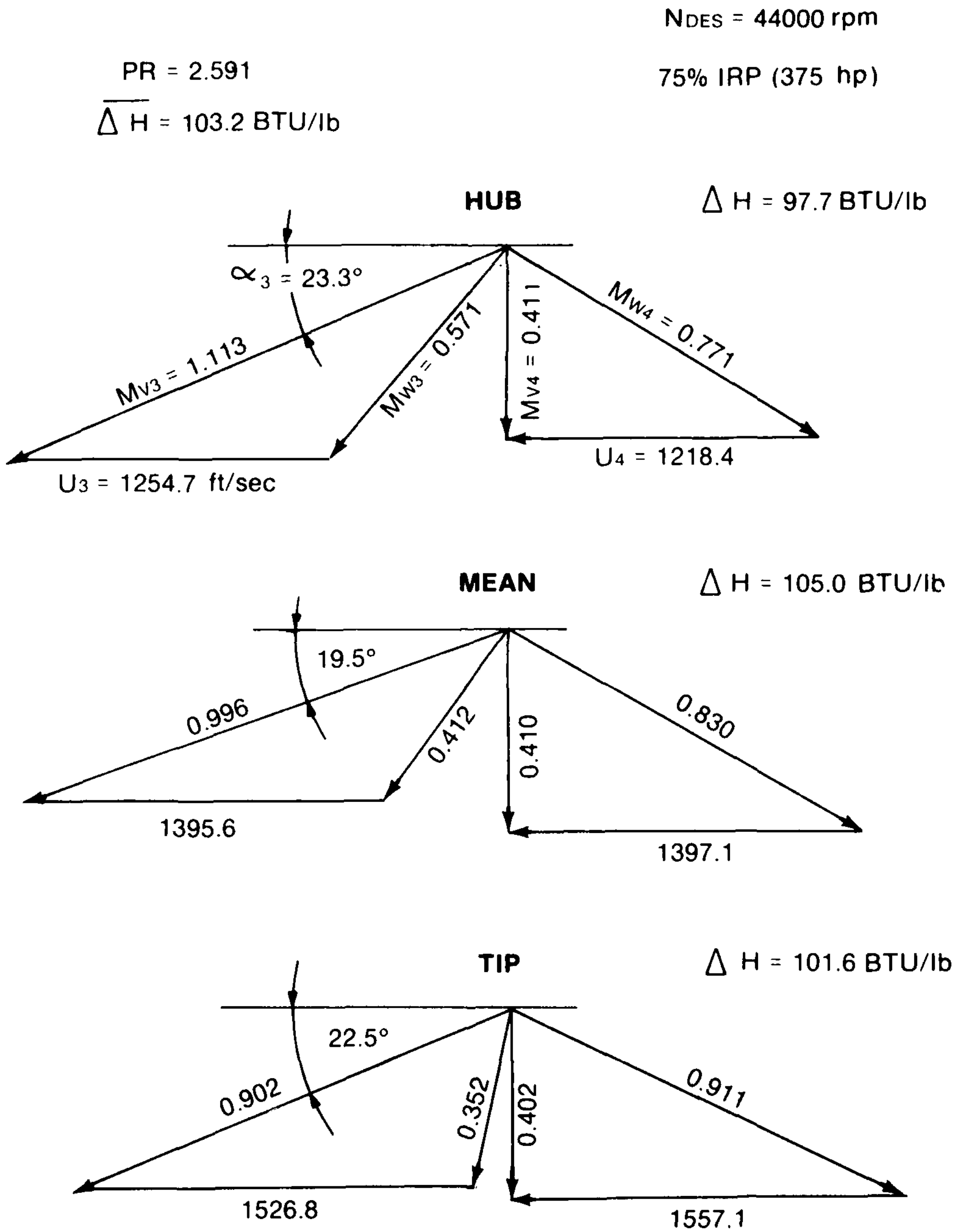


Figure 55. Velocity triangles, power turbine

design the stator in two separate sections: (a) a fixed blading that generates part of the tangential flow momentum in a channel of increasing annulus area, with a deceleration of the axial velocity component, followed by (b) a movable blading that increases the momentum to its final value with minimum axial velocity acceleration.

Figure 56 shows the meridional flow path. The flow data are listed in the program input and output printout shown in Appendix F.

With the above design provisions, the meridional velocity on the 50% streamline decreases from 550 to 480 ft/sec across the fixed stator blading (Program stations 7-9) and it increases to 668 ft/sec at exit of the variable stator (Program station 10, velocity triangles station 3). The average rotor exit Mach level (Program station 11, velocity triangles station 4) is .409 at the 375 hp design point, below .4 for the lower mission power ratings, and increases to .5 at 500 hp. The hub reaction has been selected high enough (W_4/W_3 = 1.321) to remain positive at the closed stator position for the 200 hp rating.

Single Can Burner

The burner has an air-assisted atomizing injector, and the flame tube and scroll designs are similar to those developed for a 1500 hp vehicular engine. The can volume is determined by a heat release rate of $6 \cdot 10^6$ Btu/hr·atm·ft^3 assumed at the 500 hp design conditions.

Turbine Exit Diffuser

There is sufficient axial space between the power turbine and the recuperator rear face to design an efficient diffuser without additional increase of the engine length. Thus, only part of the flow has to be reversed by 180 degrees before entering the recuperator. This has been used to decrease the curvature of the outer diffuser wall turn. Within the available length, it is possible to design an optimum annular diffuser with one splitter wall only. For the outer diffuser section (60% of the flow), the outer cone angle is 5.7 degrees and the inner core angle (average slope of the 40% streamline) is -2.2 degrees. With a total divergence angle of 7.9 degrees, and an aspect ratio L/h_i = 16, Figure 57 gives a static pressure coefficient $2\Delta P/\rho_i V_i^2$ = .72. This results in a total pressure loss of 2.4% for the diffusion from the turbine exit Mach level of .40 down to .1. For the inner diffuser section (40% of the flow),

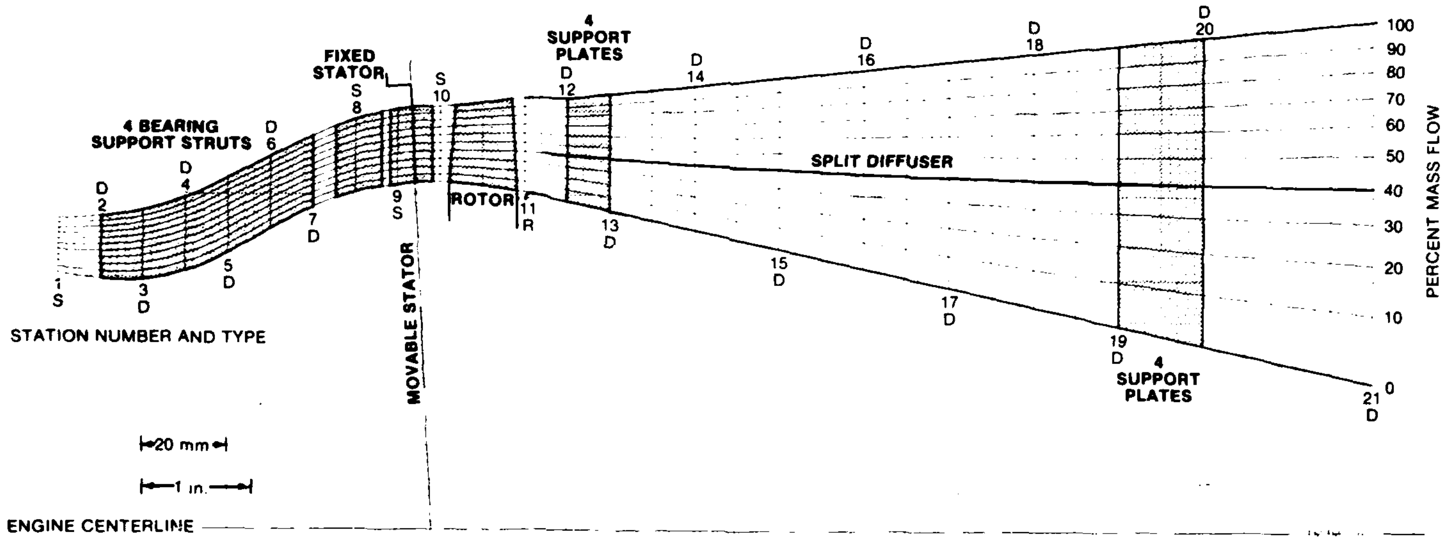


Figure 56. Meridional flowpath and streamline pattern, power turbine and diffuser.

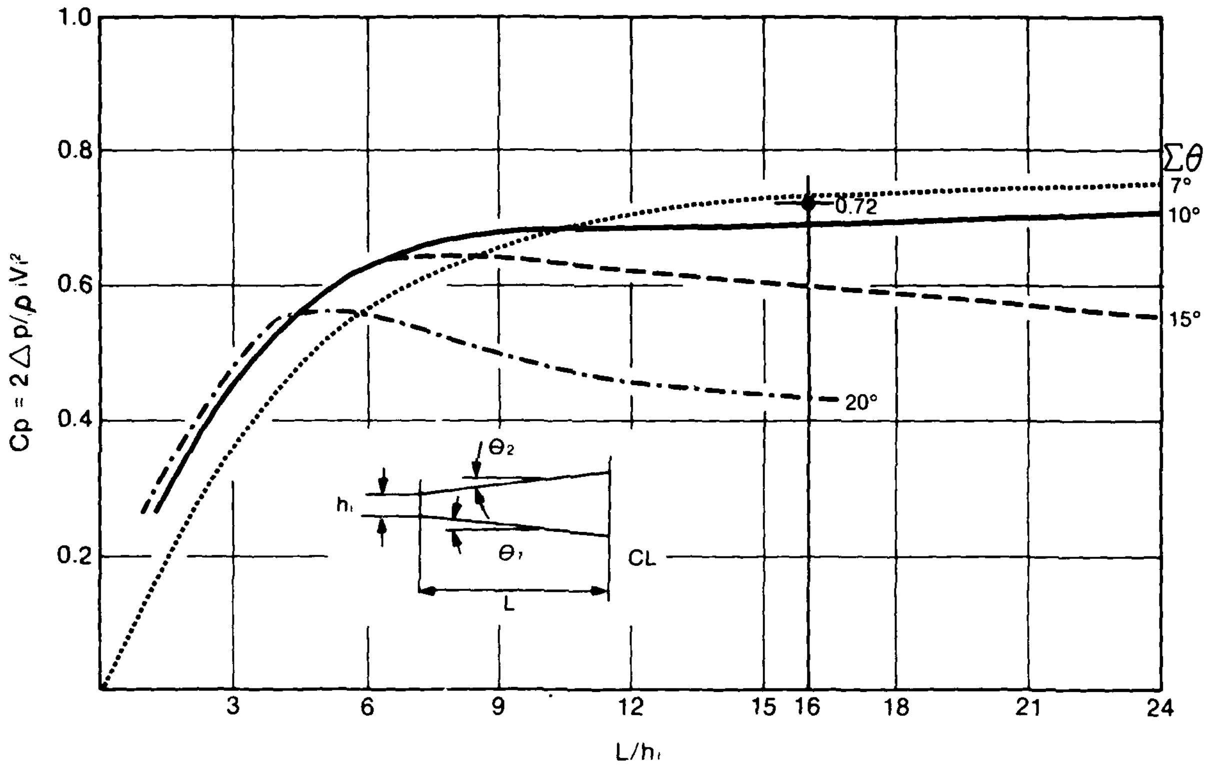


Figure 57. Performance of annular diffusers

the total divergence angle is 10.5 degrees and a slightly higher total pressure loss would be calculated. However, the inner diffuser configuration substantially departs from that with equal and opposite inner and outer core angles for which the results of Figure 57 apply. Since the overall passage area and aspect ratios are essentially identical and the wetted area per unit of mass flow is only 10% larger, the lower diffuser section is assumed to have a 10% higher total pressure loss. The overall conical diffuser pressure loss thus is 2.5% and an additional .3% has been charged for downstream flow turning, resulting in a total diffuser pressure loss of 2.8% at the 375 hp power turbine design point, which reduces to 2.3% at 60% IRP.

Exhaust Collector

Originally, an exhaust collector with sideward exit was envisioned. This collector type was found to be heavier than an annular design with axial exit and it is also less favorable for engine installation. Since the flow exits radially and must be turned toward the axial direction with minimum upstream interference, the recuperator baffle plates are extended radially beyond the outer core diameter and curved backward to provide for favorable exit conditions. The recuperator exit velocity is of the order of 20 ft/sec and the 90-degree turn results in a negligible total pressure loss.

Inlet Particle Separator

The total pressure loss of the inlet particle separator is evaluated from the value measured at the corresponding 95% design speed of the representative engine and corrected in ratio of the square of the referred mass flow rates. This yields a total pressure loss of 4.6 inches of water, which constitutes a 1.2% loss that reduces to .6% at 60% IRP.

Engine Modular Construction

Figure 58 shows an exploded cross section illustrating the main engine assembly and modular construction. Nine modules are defined as functional engine subassemblies:

1. The Gas Producer Module, which is comprised of the compressor with housing and diffuser, the forward main frame, the gas producer turbine with the hot gas scroll, and the accessory drive gears.

2. The Inlet Particle Separator Module.

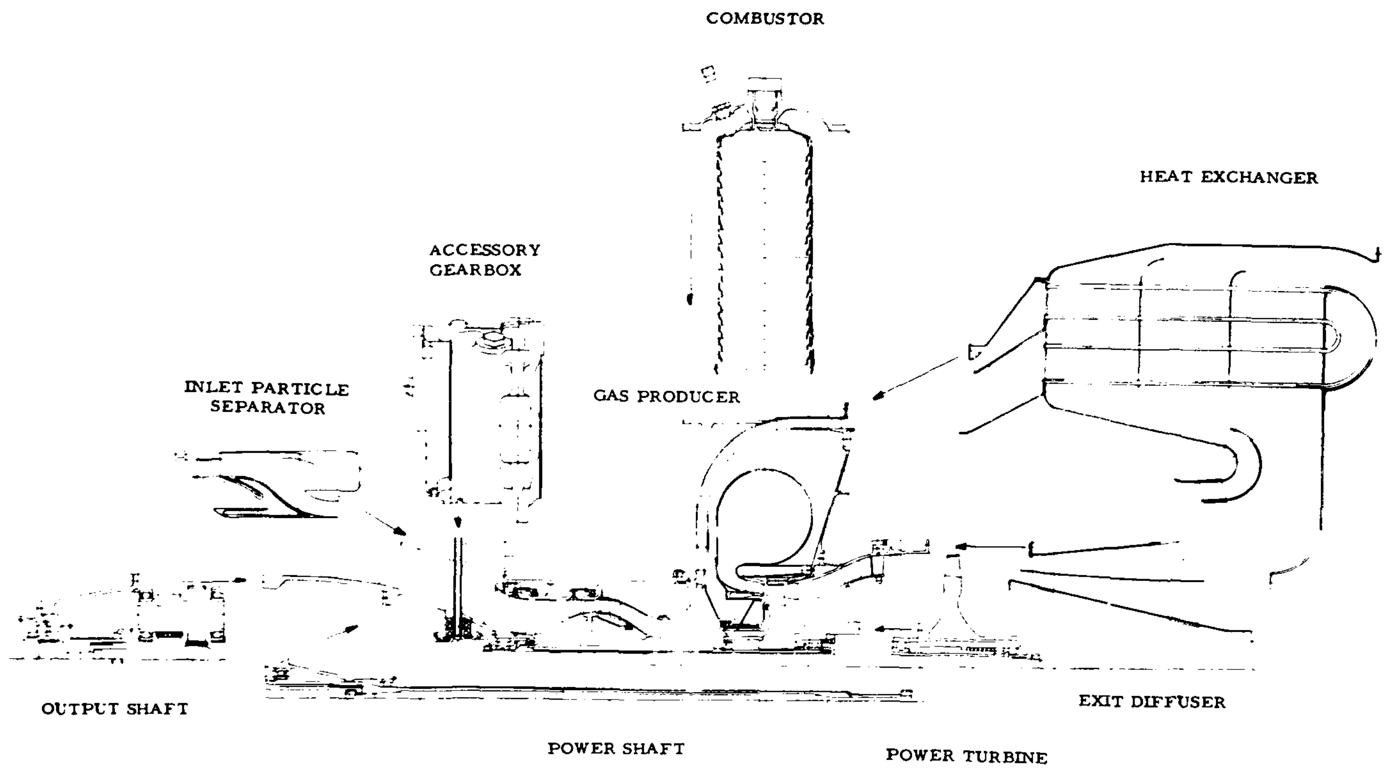


Figure 58. Engine modular construction

3. The Combustor Module.

4. The Power Turbine Module, which is comprised of the rotor disk and blade assembly and the support frame with two bearings and one seal.

5. The Power Shaft Module with forward support frame, two bearings, and the sun gear.

6. The Power Turbine Exit Diffuser Module.

7. The Recuperator Module.

8. The Output Shaft Module, which is comprised of the reduction gear with planet gear carrier and three planet gears, the output shaft with one gear, two bearings and one seal, the inner and outer support housings, and the torquemeter sensor.

9. The Accessory Gearbox Module, which is comprised of the gearbox, the fuel and oil pumps, the fuel control, the starter/generator, the alternator/exciter/regulator group, and the particle separator scavenge blower.

MECHANICAL DESIGN CONSIDERATIONS

Gas Producer

The compressor is scaled from the 800-hp representative engine. Its rotational speed, however, is lower than the scaled speed, so that all stresses are lower than those of the representative compressor.

The first compressor rotor is an integrally forged blade-disk of Ti (6Al-4V) material. The highest stress is in the axial spacer under the exit guide vane and is 80,000 psi. The material has a 2% yield strength of 96,000 psi. The disk has a life in excess of 80,000 cycles.

The second rotor is an integrally cast Custom 450 alloy design. The highest stress is at the disk bore and is 114,000 psi. The material .2% yield strength is 127,000 psi. The disk has a life in excess of 50,000 cycles.

The centrifugal compressor is machined from a forging of Ti (6 Al-2 Sn-4Zr-6Mo). The maximum stress in the disk is 62,000 psi. The material has a .2% yield strength of 100,000 psi. The disk life is

in excess of 100,000 cycles. The stages are designed so that the blades fail before the disks, with failure occurring above 130% of design speed. The engine casing is designed to contain the blades.

The axial and centrifugal rotors and the conical spacer are mounted on the compressor shaft and clamped axially by a nut at the back face of the centrifugal rotor. The balanced rotor assembly is not disassembled for engine buildup.

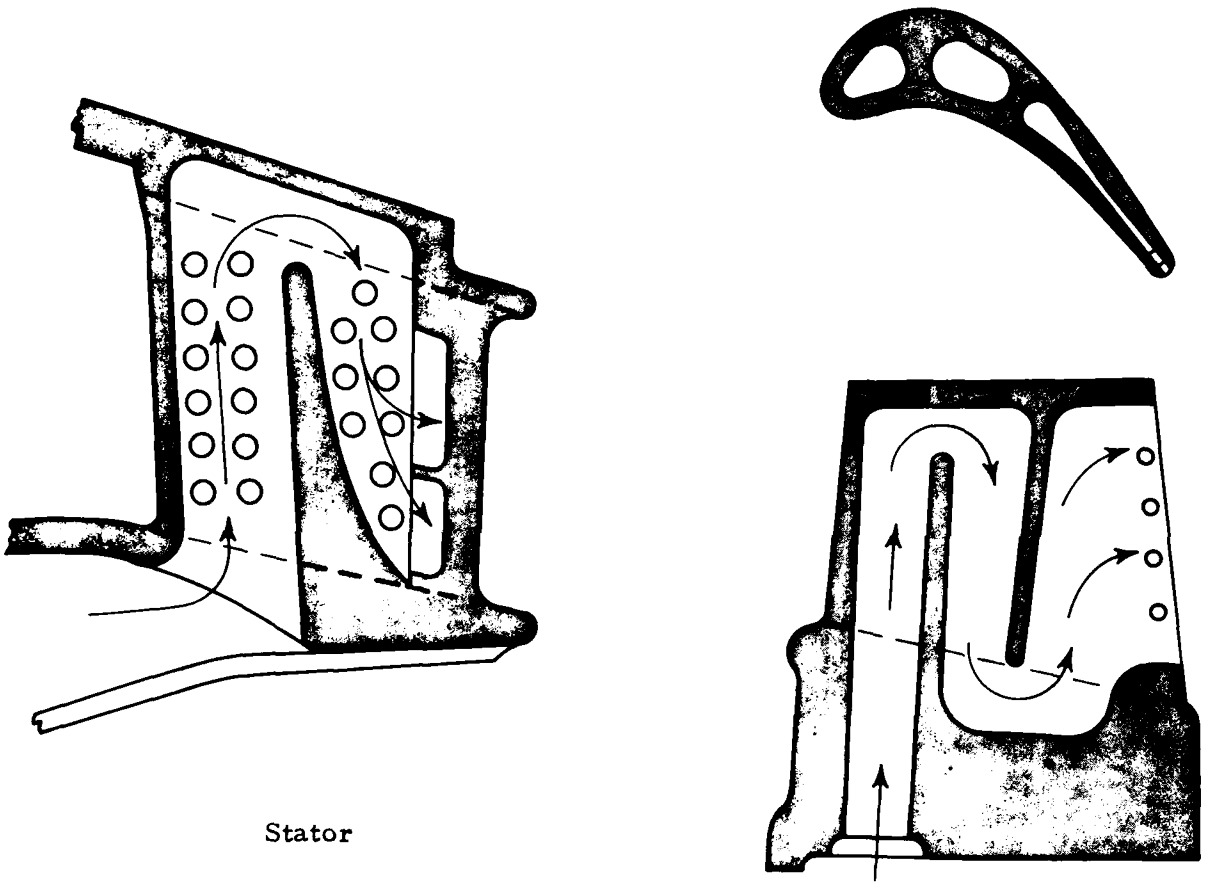
The forward main frame consists of an outer casing connected to an inner casing by six radial struts. This is a single casting of MAG AZ 91 alloy. The outer casing provides the attachment points for the particle separator at the forward face, the accessory groups on top, and the compressor casing at the rear phase. The inner casing provides the attachment points for the output shaft assembly at the forward face, the power shaft assembly and the accessory gear drive at the inner flanges, and the forward end of the gas producer rotor at the rear face.

The compressor casing is a double layer structure. The inner housing supports the variable inlet, variable first stage, and fixed exit guide vanes. It is split axially to fit over the assembled rotor. The outer casing is a full cylinder which slides over the inner assembly. Both casings are of Ti (6 Al-4V) material. The variable vanes are of cast Custom 450 alloy and the fixed exit guide vanes are of Steel 321.

The air diffuser, which provides the rear main frame for the engine, is a cast/sheet metal welded/brazed assembly of Inco 718 alloy. The vane assembly is cast and fits into the vertical wall of the housing. After the diffuser, the inner and outer walls of the assembly are connected by struts which form passages for oil to and from the rear bearing package. The rear main frame provides the support for the single can combustor and the hot gas collector scroll.

The air-cooled gas producer turbine nozzle is an integral casting which is brazed to a support structure. The stator cooling scheme is shown on Figure 59.

The turbine wheel has cooled blades of DSMM 247 alloy secured by a root fastening to a forged disk of LC Astroloy. The blade cooling scheme is shown on Figure 59. The peak disk stress is 132,000 psi. The .2% yield strength of LC Astroloy is 125,000 psi. The disk life is estimated to be 6000 cycles, which is adequate for engine demonstration purposes but not sufficient for a production engine. The 360-degree scroll is made of .032 in Hastalloy-X sheet metal with spot-welded M956 cooling air louvers.



Stator

Rotor

Figure 59. Stator and rotor blade convective cooling schemes

Inlet Particle Separator

The separator system consists of a fully anti-iced annular separator, a scavenge flow collecting manifold, and a self-bypassing scavenge blower. The scavenge blower is mounted on the accessory gearbox and connects to the separator with a flexible elastomer tube. System arrangement is shown on Figure 60. The self-cleaning particle separator is shown on Figure 61. It uses the inertial principle with an inner and an outer capture area. The flow divider is supported by six hollow radial struts which are used to scavenge the inner capture area outboard to a wrap-around manifold. Anti-icing is accomplished by conductive heating of critical flow-path elements by means of gas bleed from the power turbine section.

Combustor

The combustor is a single can located at the top left side of the engine. The liner, igniter, and fuel nozzle are supported by the combustor chamber cover. All three components are withdrawn together for ease of inspection and replacement.

The combustor liner is made of .032-in. Hastalloy-X sheet metal and fitted with spot-welded M956 cooling air louvers.

Power Turbine

The power turbine wheel has individually cast C101 alloy blades secured to an LC Astroloy forged disk. The peak disk stress is 132,000 psi. The .2% yield strength of LC Astroloy is 127,000 psi. The estimated disk life is 25,000 cycles.

The wheel is supported on two preloaded ball bearings at the rear end of the power turbine shaft. The drive spline has 17 teeth with 30-degree pressure angle, fillet root side fit, 24/48 pitch, .7-inch pitch diameter, and a 5-inch length. The assembly is bolted to the rear face of the main support frame.

Power Shaft

The power shaft fits into two pilot diameters inside the power turbine rotor shaft. The drive spline has 24 teeth with 30-degree pressure angle, fillet root side fit, 48/96 pitch, .5-inch pitch diameter, and 1.00-inch length.

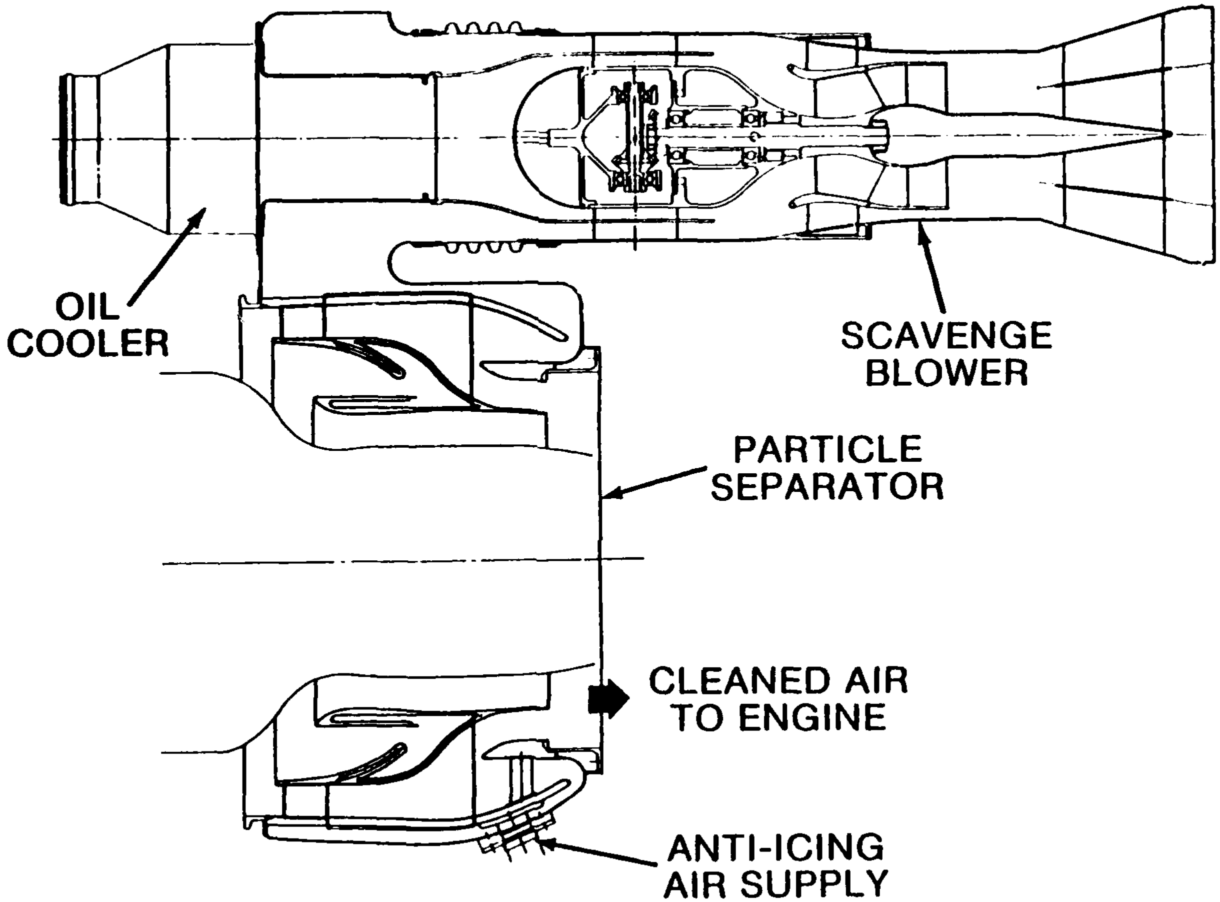


Figure 60. Inlet particle separator system

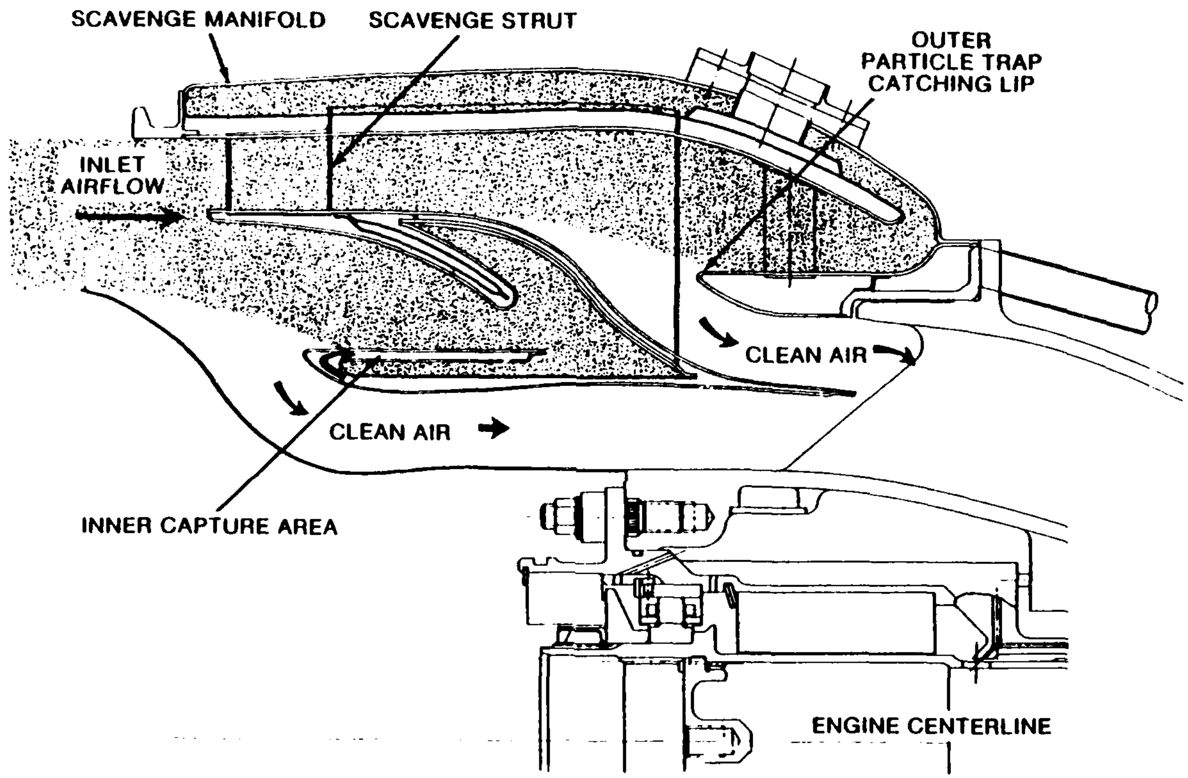


Figure 61. Particle separator principle

The critical speed conditions can be evaluated on the basis of the representative engine. In general, the natural bending frequency of a shaft can be calculated with the following formula:

$$f = kD\sqrt{1 + \beta^2}/L^2 \qquad (17)$$

where D is the outer shaft diameter, L the shaft length, and β the ratio of the shaft inner and outer diameters. For similar shafts, the frequency is inversely proportional to their lengths. The critical speed margin thus is retained if the rotational speed is varied in the same proportion. For the representative engine, the critical speed margin is 38.3%. For the proposed engine, the critical speed margin would be retained with a similar shaft of 14.17-inch length and a rotational speed of 36,720 rpm. The natural frequency then would be 50,796 cpm. The actual shaft length is 13.55 inches, which yields f = 55,550 cpm. With an actual rotational speed of 44,000 rpm, the critical speed margin is reduced to 26.3%, which is considered adequate for engine demonstration purposes but not sufficient for a production engine.

An analytical investigation indicates that the natural frequency of a hollow shaft can be increased by 10-15% by applying a boron fiber layer inside the shaft. An experimental manufacturing program is presently underway at Lycoming for composite shafts. Figure 50 thus indicates such an application for the proposed engine.

Power Turbine Exit Diffuser

The PT exit diffuser is a welded Hastalloy-X sheet metal assembly.

Conceivably the diffuser could be made part of the recuperator module. This, however, would require a sliding ring seal joint between the diffuser outer wall and the power turbine outer casing, and the gas forces would be transmitted to the recuperator header. The flange attachment is simpler and structurally sounder.

Recuperator

The recuperator core consists of 2750 U-tubes of Inco 625 alloy with .15-inch outside diameter and .004-.006-inch wall thickness. The inner core section has 9 rows of tubes with a tangential spacing X_T = 1.213 D = .182 inch. The outer core section has 8 rows of tubes with a tangential spacing X_T = 1.373 D = .206 inch. Radial spacing of the rows is X_L = 1.0D = .15 inch. The tubes are brazed into a forward

header and three flow guiding and support baffles. The rear baffle extends radially inward to be bolted to the inner flange of the exhaust diffuser. The main support is at the forward outer flange, which is bolted to the main engine frame. There is enough flexibility in the rear baffle wall to accommodate differential axial expansions of the recuperator/diffuser assembly.

The exhaust collector is a Hastalloy-X sheet metal structure bolted to the recuperator header.

Output Shaft

With 20,000 rpm, the output torque at IRP (500 hp) is 1575 inch-pounds. The output shaft is designed for a nominal torque of 1890 inch-pounds. The shaft spline has 25 teeth with 30-degree pressure angle, fillet root side fit, 20/40 pitch, 1.25-inch pitch diameter, and .5-inch length. The tooth bearing stress is 4838 psi.

The reduction gear is a double planetary design with fixed planets. The arrangement and gear design particulars are shown on the following sketch and Table 15.

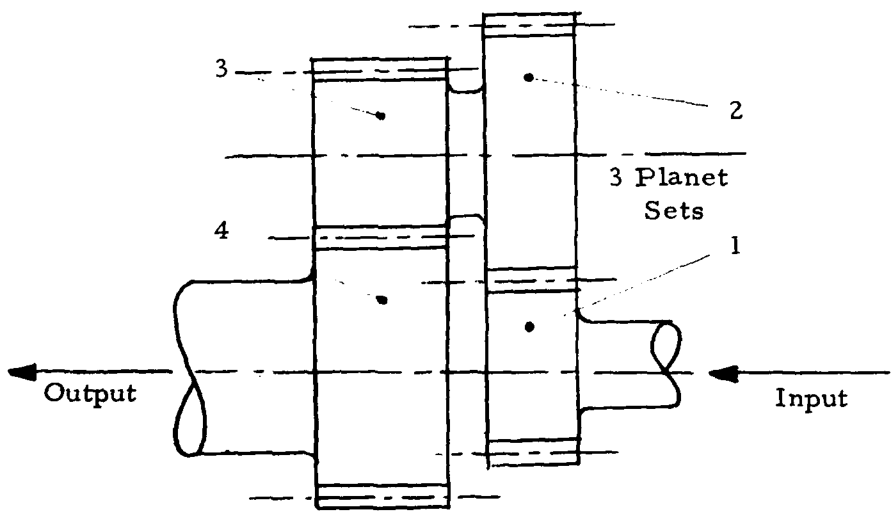


TABLE 15. REDUCTION GEAR DESIGN PARTICULARS

Gear	Transmitted Load (lb)	Face Width (in)	Pitch Dia. (in)	Pitch (in^{-1})	Number of Teeth	Bending Stress (psi)	Hertz Stress (psi)
1	481	0.75	1.1905	21	25	31,338	123,452
2	481	0.75	2.0952	21	44	31,338	123,452
3	686	0.85	1.4706	17	25	30,693	133,665
4	686	0.85	1.8235	17	31	30,693	133,665

Gear ratio = 44/25 · 31/25 = 2.1824

Accessory Gearbox

The engine accessories are mounted on top of the engine to reduce vulnerability and provide maximum accessibility. Drive pads are located on both forward and aft faces of the gearbox to minimize weight, cost and bulk.

A top view of the gearbox arrangement is shown schematically on Figure 62. The accessory gear set is driven by a bevel gear at the forward end of the gas generator.

ENGINE WEIGHT

Engine weight has been estimated on the basis of components and parts similarity with existing engines. The weight of new components and parts has been calculated from the dimensions and materials defined by the preliminary design.

Table 16 shows the weight of the engine broken down in components and modules. This calculated weight is 38.4 pounds heavier than estimated on the basis of the parametric study assumptions (213.2 pounds). The latter, however, did not include 18.5 pounds for the output gear and shaft assembly. The remaining 19.9 pounds are essentially due to heavier midframe and recuperator connecting duct assemblies than initially estimated.

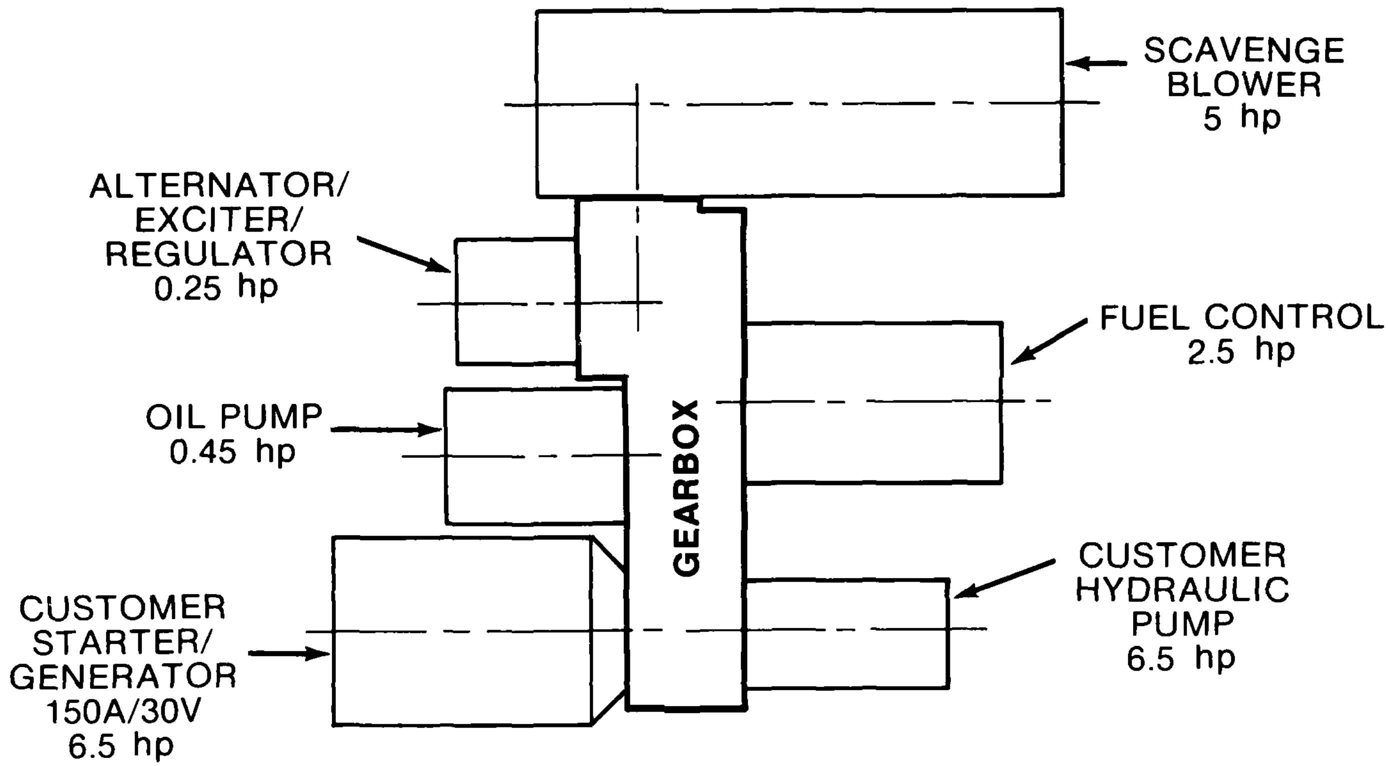


Figure 62. Accessory gearbox module

TABLE 16. ENGINE WEIGHT BREAKDOWN

	ITEM	Weight (lb)
1.	Compressor (includes Inlet Housing, Front Bearing and Accessory Drive Gear Packages)	21.14
2.	Burner (includes 360-degree Scroll and Mid-frame Assembly)	23.90
3.	Gas Producer Turbine (includes Rear Frame Assembly and Bearing Package)	26.14
4.	Power Turbine (includes Power Shaft with Boron Insert, Variable Stator Actuator System, and Front and Rear Bearing Packages)	18.50
5.	Recuperator (includes Exhaust Gas Collector)	77.30
6.	Gas Diffuser and Recuperator Connecting Ducts	4.88
7.	Output Gear and Shaft Assembly	18.47
8.	Inlet Particle Separator and Scavenge Blower	19.20
9.	Accessory Gearbox Module (includes Fuel Control, Fuel and Oil Pumps, and Alternator/Exciter/Regulator)	32.10
10.	Piping and Miscellaneous	10.00
	Engine Weight (excluding Starter/Generator and Customer Hydraulic Pump)	251.63

ENGINE INSTALLATION AND INSTALLED PERFORMANCE

ENGINE INSTALLATION

Figure 63 shows the installation drawing of the proposed engine. There are two pairs of mounting pads located on the lower engine half, 45 degrees either side of bottom center. The first pair is on the engine inlet housing. The second pair is on the outer periphery of the compressor diffuser wall near the engine gravity center plane and is used for all installations. Only one optional forward mount is used. The other provides a nonredundant support for safe mount failure.

INSTALLED ENGINE PERFORMANCE

To calculate the installed engine performance, the pressure loss of the inlet particle separator (.6% at 60% IRP) is added to the cycle losses. Furthermore, the 2% diffuser pressure loss has been increased to 2.3% at 60% IRP. The mechanical loss of the power turbine shaft has been increased from .5% to 1.5% to account for the output reduction gear. Inlet particle separator and customer accessory power has been estimated as follows:

Inlet Particle Separator Blower	8.2 hp
Customer Hydraulic Pump	6.5 hp
Generator	6.5 hp
Total	21.2 hp (40-100% IRP)

This power is assumed to drop to 10.6 hp at idle (50 hp) and to increase gradually to 21.2 hp at 40% IRP (200 hp).

Finally, a minimum 2% of customer bleed extracted at exit of the compressor and .05 lb/s anti-icing gas extracted at exit of the power turbine, have been assumed.

With those installation losses and bleed flow and accessory power requirements, the engine power achievable with IRP $T_{4.0} = 2750^{\circ}R$ is reduced to 460 hp. Figure 64 shows the compressor operating line determined by assuming $T_{4.0} = 2520^{\circ}R$ and the same surge margin at 60% IRP, which requires a slight resetting of the gas producer turbine nozzle. Uninstalled operating points for 50, 200, 300, and 500 hp have been added for comparison.

Engine Upscaling

If the installed engine has to deliver 500 hp at the IRP point, the maximum cycle temperature must be raised to a level that is substantially beyond the present state-of-the-art for a 500-hp engine (2750-2800°R). Therefore, it is necessary to scale up the engine.

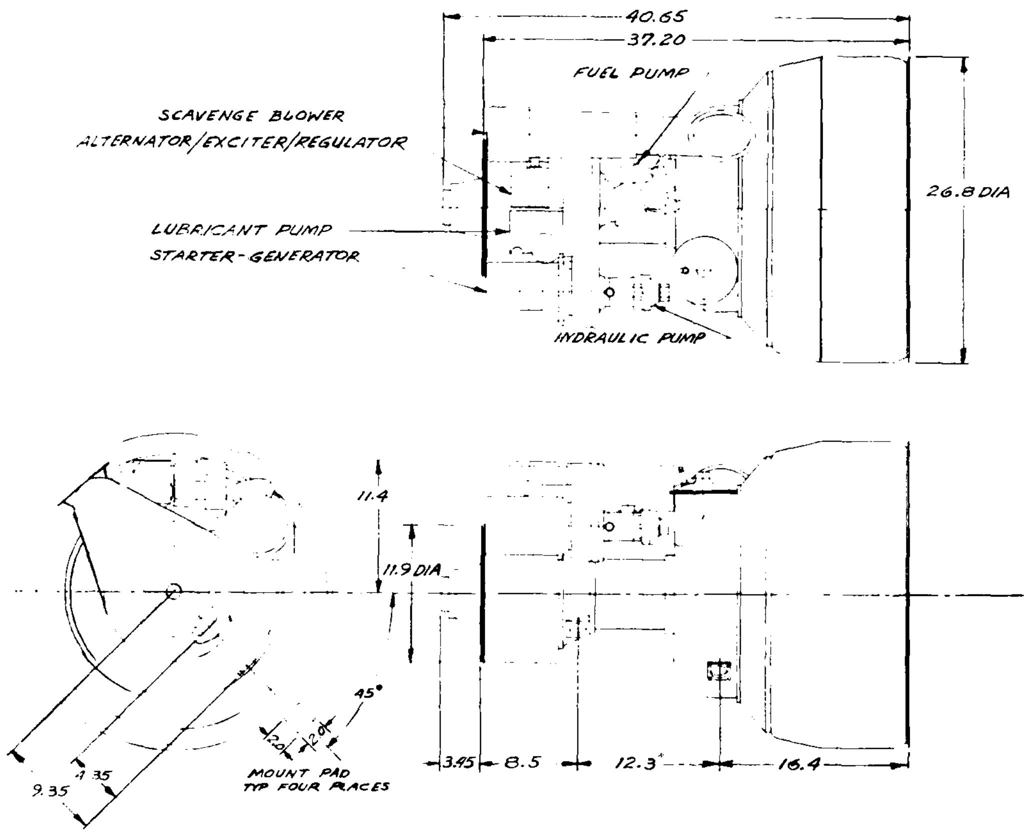


Figure 63. Installation drawing

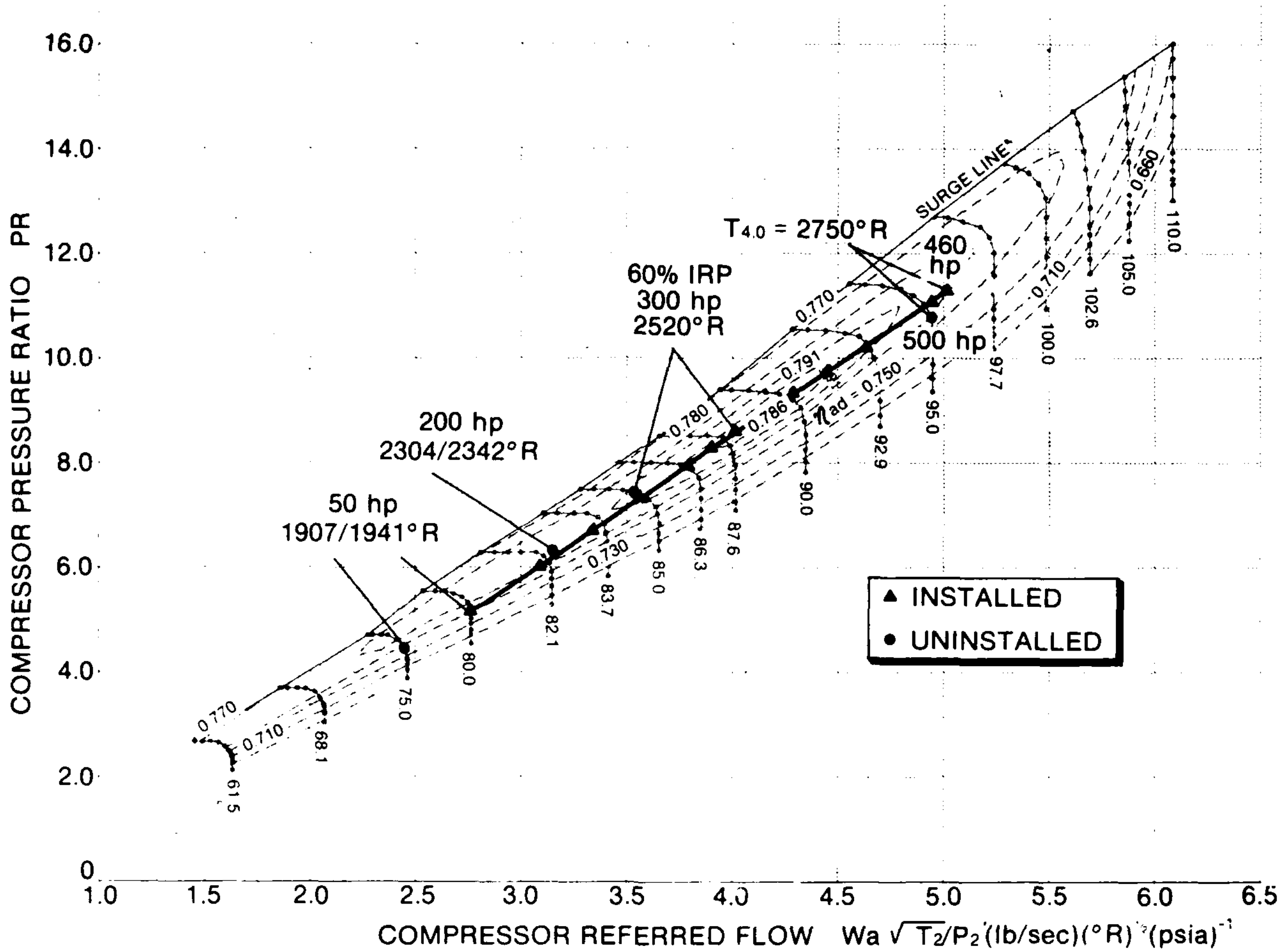


Figure 64. Compressor operating line for installed conditions

Optimum 60% IRP conditions $T_{4.0} = 2520^{\circ}R$ and PR = 7.4 result in a flow scaling factor of 1.150. Table 17 lists the uninstalled and installed performances for the mission ratings. Complete installed performance data are given in Appendix C.

TABLE 17. COMPARISON OF UNINSTALLED AND INSTALLED PERFORMANCE OF THE PROPOSED ENGINE

Power (hp)		50	200	275	375	500	Mission Fuel Weight (lb)
SFC (lb/hp-hr)	Uninstalled	0.977	0.472	0.427	0.401	0.412	229.5
	Installed*	1.141	0.542	0.482	0.444	0.448	257.9 (+12.4%)

* Engine scaled up for 15% mass flow increase.

Inlet particle separator system and customer power and bleed requirements cause a substantial decrease of the engine SFC performance and specific power. Those effects must be taken into account by specifying the required installed power at the design stage.

For the upscaled engine, the components weights given in Table 16 must be modified. It is assumed that the radial dimensions only will be increased in the ratio $\sqrt{1.150} = 1.072$. The weight of components 1 - 6 and 8 thus increases by 15%, while the weight of components 7 (output gear and shaft assembly), 9 (accessories), and 10 (piping and miscellaneous) remains unchanged.

The engine weight thus goes up from 251.6 to 280.3 lbs., and the radial dimensions quoted in Figures 50 and 63 increase by 7.2% for installed 500 hp at IRP.

ENGINE COST AND FUEL COST BREAK-EVEN POINT WITH NON-REGENERATIVE ENGINE

ENGINE COST

Engine cost has been estimated on the basis of components and parts similarity with existing engines. For new items, standard experimental costing procedures have been used.

Cost reduction for the smaller engine size takes into account the fact that the resulting materials savings tend to be offset by the smaller manufacturing tolerances required. Table 18 lists the manufacturing cost in 1979 dollars of one experimental engine broken down in major components. Components similarity with existing engines or standard experimental hardware costing procedure is indicated in the last column.

Figure 65 shows engine manufacturing cost versus engine number with an assumed 80% learning curve slope. The cost of the 100th engine is $140,942.00. Based on a vendor quotation, the cost of the hydromechanical fuel control for a production rate of 250 engines per year is $8,708.00. The cost of the starter/generator is $800.00. Engine inspection, assembly and testing cost has been estimated on the basis of T53 experience and is $4,504.00. Finally, engineering support cost is estimated to be 5% of the engine manufacturing cost, i.e., $7,047.00. The total cost of the 100th engine thus is 140,942 + 8,708 + 800 + 4,504 + 7,047 = $162,001.00 (1979 dollars). This cost does not include packing and shipping, G and A and profit.

FUEL COST BREAK-EVEN POINT

With the above engine cost estimate, an approximate fuel cost figure for helicopter system + mission life fuel cost break-even point with a non-regenerative engine has been calculated on the basis of equivalent gross weight. The cost of the nonregenerative engine is taken from Table 18 to be that of the proposed engine minus the recuperator and the gas diffuser and recuperator connecting ducts, corrected for the smaller size by a factor 84.852/90.706 = .9355 and for estimated .85 factored inspection, assembly, testing, and engineering support costs. Thus:

Cost of Engine without Recuperator (Items 1, 2, 3, 4, 7, 8)	$384,219.00
Adjustment for Second Gas Producer Turbine Stage	25,710.00
Adjusted Cost	409,929.00

TABLE 18. EXPERIMENTAL ENGINE COST BREAKDOWN
(1979 $K)

ITEM	1.1 Fact. Material Cost	3.51 Fact. Labor Cost at $32.00/hr	Total Cost	Engine Similarity or Standard Costing
1. Compressor (includes Inlet Housing, Front Bearing, and Accessory Drive Gear Packages)	74.540	15.898	90.438	800 hp Repr. Engine
2. Burner (includes 360 degree Scroll and Mid-frame Assembly)	22.709	38.242	60.951	1500 hp Regen. Engine
3. Gas Producer Turbine (includes Rear Frame Assembly and Bearing Package)	29.141	40.441	69.582	600 hp Engine
4. Power Turbine (includes Power Shaft with Boron Insert, Variable Stator Actuator System, and Front and Rear Bearing Packages)	21.943	34.363	56.306	800 hp Repr. and 1500 hp Regen. Engines
5. Recuperator (includes Exhaust Gas Collector)	22.241	104.226	126.467	Standard Costing
6. Gas Diffuser and Recuperator Connecting Ducts	7.078	8.660	15.738	Standard Costing
7. Output Gear and Shaft Assembly	61.821	2.291	64.112	Standard Costing
8. Inlet Particle Separator and Scavenge Blower	6.641	36.189	42.830	800 hp Regen. Engine
9. Accessory Gearbox Module (includes Fuel and Oil Pumps and Alternator/Exciter/Regulator)	72.181	13.243	85.424	800 hp Repr. Engine
10. Piping and Miscellaneous	3.226	5.651	8.877	800 hp Repr. Eng.
Engine Manufacturing Cost (excluding Fuel Control and Starter/Generator)	321.521	299.204	620.725	

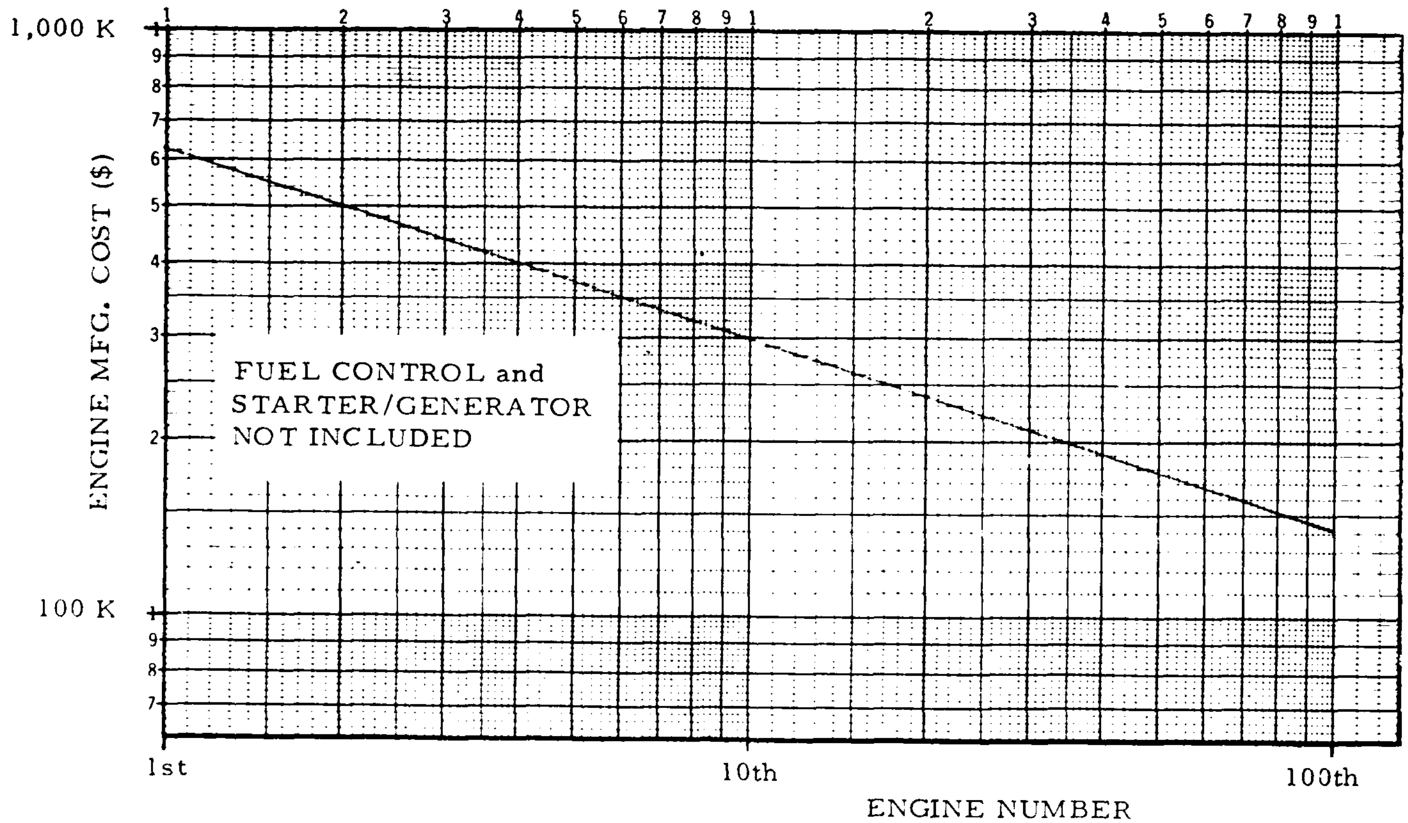


Figure 65. Engine manufacturing cost

0.9355 Factored Cost	$383,489.00
Accessory Gearbox Module	85,424.00
Piping	8,877.00
Total	$477,790.00
100th Engine Cost with 80% Learning Curve Slope	$108,487.00
Fuel Control + Starter/Generator	9,508.00
0.85 Factored Engine Inspection, Assembly, Testing, and Engineering Support	9,918.00
Nonregenerative Engine Cost	$127,913.00
Recuperative Engine Cost	$162,001.00
Cost Differential	$ 34,088.00

The weight of the nonregenerative engine is taken from Table 16 and corrected by the size factor .9355:

$$W_e = .9355\,(251.63 \underbrace{-77.3}_{\text{recuperator}} \underbrace{-4.88}_{\text{diffuser + ducts}} \underbrace{+10.0}_{\text{second gas producer turbine stage}}) = 167.9 \text{ lb}$$

Table 19 compares the consumed mission fuel, the embarked fuel with 25% reserve, the engine, and the engine + mission fuel weights.

TABLE 19. ENGINE AND FUEL WEIGHT COMPARISON

Engine Type	Consumed Mission Fuel Weight (lb)	Embarked Fuel Weight (lb)	Engine Weight (lb)	Engine + Mission Fuel Weight (lb)
Recuperative	229.5	286.9	251.6	538.5
Nonregenerative	281.0	351.3	167.9	519.2

The mission life fuel savings of the recuperative engine is 2500 (281.0 - 229.5) = 128,750 pounds. With the engine acquisition cost differential of $34,088.00 in favor of the nonregenerative engine, the fuel break-even cost is 34,088/128,750 = $ .265/pound, or $1.78/gallon. This figure applies for a helicopter of fixed gross weight that has a payload penalty of 38.6 pounds with two recuperative engines. On the basis of equivalent mission capability, the fuel break-even cost would be slightly higher.

The above fuel break-even cost indicates that a 500 hp recuperative helicopter engine of current state-of-the-art technology will become competitive with a nonregenerative engine within the 1980-85 time period.

The fuel break-even cost figure obviously is very sensitive to the actual cost of the recuperator hardware. With the 80% learning curve slope used above, the tubular recuperator cost for the 100th engine is $28,716.00. The cost of the waveplate recuperator of the 1500 hp vehicular engine constitutes 12.5% of the entire engine cost. The engine has a more complex two-spool gas generator and a two-stage power turbine, but does not have an inlet particle separator system. This only partly compensates for the higher turbomachinery cost. Consequently, a 15% waveplate recuperator cost factor can be assumed for the 500 hp engine. From Table 18, the basic cost of the turbomachinery is $494,258.00 (Items 1-4, 6-10). The full experimental engine cost thus is 494,258/.85 =581,480.00 and with the 80% learning curve slope C_e= 132,031 + 8,708 + 800 + 4,504 + 7,047 = $153,090.00.

The nonregenerative engine cost is $127,913.00, and the engine cost differential $25,177.00. The fuel break-even cost thus is 25,177/128,750 = $ .196/pound, or $1.31/gallon on the basis of fixed helicopter gross weight. This reflects the lower cost of the waveplate recuperator - $19,805.00. On the other hand, the mission payload penalty as compared to the helicopter powered by engines with tubular recuperators of .004-inch tube thickness is 2 (137 -77) = 120 pounds (Table 10).

CONCLUSION AND RECOMMENDATIONS

For a 500-hp engine of present state-of-the-art technology, the recuperative cycle offers an 18% fuel savings over the nonregenerative cycle. For a typical 2-hour helicopter mission, the engine + mission fuel weight is 3.7% higher than for a nonregenerative engine. The fuel savings compensate for the higher engine acquisition cost if fuel cost is assumed to escalate to approximately $1.80/gallon (1979 dollars).

The 500-hp recuperative helicopter engine thus will become competitive with the nonregenerative engine within the 1980-1985 time period.

The development of a 2300°F, 1650-1700 ft/sec tip speed, single-stage ceramic gas producer turbine and of a low cost tubular recuperator core manufacturing technique are the two essential means of improving the overall economy of the recuperative engine. In the foreseeable future, the use of a ceramic nozzle assembly will increase the fuel savings over the nonregenerative engine to 21%.

The fuel savings afforded by variable power turbine stator geometry are substantial, but their realization requires a design with minimum additional aerodynamic losses. This problem has been addressed in the present study by (a) allowing a substantial increase of cycle temperature from part to full power, thereby minimizing the stator setting angle variation; (b) designing the power turbine for the 75% IRP condition, i.e., opening the stator toward IRP and closing toward part power, thereby minimizing the aerodynamic stator-rotor blading mismatch; and (c) designing a stator with concentric spherical inner and outer channel walls, thereby minimizing stator hub and tip clearances.

Efficient gas diffusion between power turbine exit and recuperator entrance is necessary. An axial diffuser with one gas flow splitter and a 0.1 exit Mach level has been designed with 97.7% total pressure recovery at 60% IRP.

The problem of the varying power turbine exit swirl has been minimized by designing the turbine with zero exit swirl at 75% IRP, which results in negative swirl at IRP and positive swirl at part-power condition. The exit swirl must be at least partly removed by the diffuser struts in order to allow for a diffuser with a substantial decrease of the inner wall radius without swirling flow separation. This minimizes the diffuser exit diameter and the outer diameter of the wraparound recuperator, resulting in a compact engine configuration.

Finally, inlet particle separator blower and customer power and bleed requirements must be taken into account during the early engine design phase.

On the basis of the results of this preliminary design study, it is recommended that the program be continued with the demonstration of a recuperative helicopter engine of the 500-hp class.

APPENDIX A: CYCLE 5 DATA

98 REGENERATIVE PROPOSAL ENGINE OFF-DES 1/29/80 POINT R5J

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

	STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES	
	1	0.14184E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.21981E+01	0.0	0.0	
	2	0.14184E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.21981E+01	0.0	0.0	
	3	0.12992E+01	0.55217E+02	0.82879E+03	0.15979E+01	0.0	0.67738E+00	0.0	0.0	
	4	0.11914E+00	0.0	0.82879E+03	0.15979E+01	0.0	0.0	0.0	0.0	
	5	0.12992E+01	0.53935E+02	0.82879E+03	0.15979E+01	0.0	0.69349E+00	0.0	0.0	
	6	0.12992E+01	0.53935E+02	0.11320E+04	0.21823E+01	0.0	0.81046E+00	0.0	0.0	50 hp
	7	0.12992E+01	0.52692E+02	0.11320E+04	0.21823E+01	0.0	0.82957E+00	0.0	0.0	
4.0	8	0.13101E+01	0.50848E+02	0.16938E+04	0.32656E+01	0.84066E-02	0.10604E+01	0.0	0.0	
4.1	9	0.13527E+01	0.50848E+02	0.16682E+04	0.32162E+01	0.81400E-02	0.10865E+01	0.0	0.0	
	10	0.14151E+01	0.20818E+02	0.13509E+04	0.26045E+01	0.77782E-02	0.24983E+01	0.0	0.0	
	11	0.14151E+01	0.20818E+02	0.13509E+04	0.26045E+01	0.77782E-02	0.24983E+01	0.0	0.0	
4.5	12	0.14151E+01	0.14973E+02	0.12548E+04	0.24191E+01	0.77782E-02	0.33476E+01	0.0	0.0	
	13	0.14151E+01	0.14830E+02	0.12548E+04	0.24191E+01	0.77782E-02	0.33801E+01	0.0	0.0	
	14	0.14151E+01	0.14830E+02	0.98382E+03	0.18967E+01	0.77782E-02	0.29931E+01	0.0	0.0	
	15	0.14332E+01	0.14736E+02	0.98382E+03	0.18967E+01	0.77782E-02	0.30505E+01	0.69043E-01	0.14696E+02	
	16	0.14332E+01	0.14736E+02	0.98382E+03	0.18967E+01	0.77782E-02	0.30506E+01	0.68353E-01	0.14696E+02	

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.15026E+03	0.68815E+02	0.37573E+01	0.76392E+00	0.84000E-01	0.14857E+01	0.39225E+05	0.38396E+01	0.20132E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.23225E-01	0.0	0.0	0.50617E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.23040E-01	0.0	0.0	0.35077E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.35714E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.95939E-02	0.0	0.0	0.85609E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.62825E-02	0.0	0.0	0.70128E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.16938E+04	0.56186E+03	0.35000E-01	0.39320E+02	0.99000E+00	0.0	0.69700E+06	0.25821E+06	0.36176E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.15102E+03	0.68815E+02	0.24424E+01	0.86500E+00	0.52381E+00	0.0	0.97297E+00	0.24424E+01	0.35630E+01
10	11 4 12 0	0.50236E+02	0.20000E+05	0.13904E+01	0.86000E+00	0.0	0.0	0.11915E+01	0.13904E+01	0.31619E+01

10
F

HT EX	STATIONS	JP1 TEMP	JP2 TEMP	JM1 CORFLO	JM2 CORFLO	JM1 DELP/PT	JM2 DELP/PT	EFFECTVNESS	EFFT SCL F.	LIMIT IND
4	5 13 6 14	0.11320E+04	0.98383E+03	0.69349E+00	0.33801E+01	0.0	0.0	0.71170E+00	0.71170E+00	0.0

NOZZL	STATIONS	GRSS THRUST	NOZZLE AREA	ACT JET VEL	IDL JET VEL	IDL VEL PR	PTIN/PAMB	DISCHG COEF	VEL COEF	NOZZLE TYPE
13	15 0 16 0	0.42629E+01	0.52900E+02	0.95684E+02	0.96650E+02	0.10028E+01	0.10028E+01	0.10000E+01	0.99000E+00	CONV

SHAFT	COMPONENTS	NET HP	ACTUAL RPM	JM1 MCH EFF	JM2 MCH EFF	JP1 MCH EFF	JP2 MCH EFF	TORQUE	NON-TURB HP	SUM ABS HP/2
14	8 0 2 0	0.50812E-02	0.68815E+02	0.99500E+00	0.0	0.10000E+01	0.0	0.38781E+00	-0.15026E+03	0.15027E+03
15	10 0 0 0	0.49984E+02	0.20000E+05	0.99500E+00	0.0	0.0	0.0	0.13126E+02	0.0	0.24992E+02

CONTR	REFERENCE NOS.			VARIABLE NOS.										
	DEPEND		INDEP	DEPEND			INDEP							
	CPT	STA	CPT	VAR	STA	PER	DAT	CONTR SWITCH	INDEP VAR	MIN LIMIT	MAX LIMIT	DEPEND DES	ABS DEP ACT	DEPEND ERR
16	14	0	14	1	0	0	1	ON	0.68815E+02	0.40000E+02	0.11500E+03	0.0	0.15027E+03	0.50812E-02
17	15	0	6	1	0	0	4	ON	0.16938E+04	0.12000E+04	0.40000E+04	0.50000E+02	0.24992E+02	-0.15594E-01
19	18	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0
20	15	0	10	1	0	0	5	OFF	0.0	0.10000E+00	0.30000E+01	0.50000E+02	0.0	0.0
21	15	0	1	1	0	0	1	OFF	0.0	0.50000E+00	0.10000E+02	0.30000E+03	0.0	0.0
22	11	0	11	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
23	12	0	12	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
25	24	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0

SCHED	REFERENCE NOS.						VARIABLE NOS.												
	SCHDVAR		ARG1		ARG2		SCHDVAR			ARG1		ARG2							
	CPT	STA	CPT	STA	CPT	STA	DAT	VAR	STA	VAR	STA	VAR	STA	SCHDVAR ACT	SCHDVAR TBL	ARG1 ACT	ARG1 TBL	ARG2 ACT	ARG2 TBL
18	10	0	0	11	0	0	0	8	0	0	1	0	0	0.86000E+00	0.88000E+00	0.14151E+01	0.14151E+01	0.0	0.0
24	10	0	15	0	0	0	0	8	0	1	0	0	0	0.86000E+00	0.86000E+00	0.49984E+02	0.49984E+02	0.0	0.0

OVERALL ENGINE PERFORMANCE DATA

AIR,LB/SEC	FUEL,LB/HR	GRS.JET THT	NET JET THT	PROP.THRUST	*TOT.NET THT	FUEL/TOTTHT	TOTTHT/AIR	OVERBRD BLEED
0.14184E+01	0.39320E+02	0.42629E+01	0.42629E+01	0.0	0.42629E+01	0.92237E+01	0.30055E+01	0.14184E-01

BRAKE SH.HP	PROP. HP	*TOT.SHFT HP	FUEL/TOTSHP	TOTSHP/AIR	EQUIV.SH.HP	FUEL/ESHP	ESHP/AIR
0.49984E+02	0.0	0.49984E+02	0.78664E+00	0.35241E+02	0.49984E+02	0.78664E+00	0.35241E+02

98 REGENERATIVE PROPOSAL ENGINE OFF-DES 1/29/80 POINT R5J

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
1	0.21473E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.33278E+01	0.0	0.0
2	0.21473E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.33278E+01	0.0	0.0
3	0.19671E+01	0.96426E+02	0.98487E+03	0.18988E+01	0.0	0.64021E+00	0.0	0.0
4	0.18038E+00	0.0	0.98487E+03	0.18988E+01	0.0	0.0	0.0	0.0
5	0.19671E+01	0.94425E+02	0.98487E+03	0.18988E+01	0.0	0.65378E+00	0.0	0.0
6	0.19671E+01	0.94425E+02	0.13647E+04	0.26310E+01	0.0	0.76959E+00	0.0	0.0
7	0.19671E+01	0.92464E+02	0.13647E+04	0.26310E+01	0.0	0.78592E+00	0.0	0.0
8	0.19951E+01	0.89227E+02	0.22524E+04	0.43424E+01	0.14177E-01	0.10612E+01	0.0	0.0
9	0.20595E+01	0.89227E+02	0.22158E+04	0.42720E+01	0.13727E-01	0.10865E+01	0.0	0.0
10	0.21539E+01	0.32134E+02	0.17642E+04	0.34013E+01	0.13117E-01	0.28154E+01	0.0	0.0
11	0.21537E+01	0.32134E+02	0.17642E+04	0.34013E+01	0.13117E-01	0.28152E+01	0.0	0.0
12	0.21537E+01	0.15456E+02	0.15234E+04	0.29370E+01	0.13117E-01	0.54383E+01	0.0	0.0
13	0.21537E+01	0.15066E+02	0.15234E+04	0.29370E+01	0.13117E-01	0.55795E+01	0.0	0.0
14	0.21538E+01	0.15066E+02	0.11906E+04	0.22955E+01	0.13117E-01	0.49327E+01	0.0	0.0
15	0.21566E+01	0.14809E+02	0.11906E+04	0.22955E+01	0.13117E-01	0.50248E+01	0.11453E+00	0.14696E+02
16	0.21566E+01	0.14807E+02	0.11906E+04	0.22955E+01	0.13117E-01	0.50256E+01	0.11338E+00	0.14696E+02

200 hp

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.34415E+03	0.82380E+02	0.65614E+01	0.78117E+00	0.84000E-01	0.14993E+01	0.46957E+05	0.67274E+01	0.30479E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.20747E-01	0.0	0.0	0.50617E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.20775E-01	0.0	0.0	0.35077E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.35714E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.25319E-01	0.0	0.0	0.85609E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.17063E-01	0.0	0.0	0.70128E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.22524E+04	0.88768E+03	0.35000E-01	0.10039E+03	0.99000E+00	0.0	0.10142E+07	0.23959E+06	0.17787E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.34594E+03	0.82380E+02	0.27767E+01	0.86500E+00	0.52381E+00	0.0	0.10106E+01	0.27767E+01	0.35630E+01
10	11 4 12 0	0.20100E+03	0.20000E+05	0.20788E+01	0.81700E+00	0.0	0.0	0.10426E+01	0.20788E+01	0.35630E+01

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HT EX  STATIONS     JP1 TEMP     JP2 TEMP    JM1 CORFLO  JM2 CORFLO JM1 DELP/PT JM2 DELP/PT EFFECTVNESS EFFT SCL F.  LIMIT IND
  4    5 13  6 14  0.13647E+04 0.11906E+04 0.65378E+00 0.55795E+01 0.0         0.0         0.70530E+00 0.70530E+00 0.0

NOZZL  STATIONS    GRSS THRUST NOZZLE AREA ACT JET VEL IDL JET VEL IDL VEL PR   PTIN/PAMB  DISCHG COEF  VEL COEF   NOZZLE TYPE
 13  15   0 16  0  0.11674E+02 0.52900E+02 0.17417E+03 0.17592E+03 0.10077E+01 0.10077E+01 0.10000E+01 0.99000E+00    CONV

SHAFT COMPONENTS      NET HP     ACTUAL RPM JM1 MCH EFF JM2 MCH EFF JP1 MCH EFF JP2 MCH EFF    TORQUE    NON-TURB HP SUM ABS HP/2
 14   8  0  2  0   0.63232E-01 0.82380E+02 0.99500E+00 0.0         0.10000E+01 0.0         0.40313E+01-0.34415E+03 0.34418E+03
 15  10  0  0  0   0.19999E+03 0.20000E+05 0.99500E+00 0.0         0.0         0.0         0.52519E+02 0.0         0.99996E+02

CONTR  REFERENCE NOS.    VARIABLE NOS.
       DEPEND  INDEP      DEPEND     INDEP
       CPT STA   CPT     VAR STA PER   DAT   CONTR SWITCH  INDEP VAR    MIN LIMIT    MAX LIMIT   DEPEND DES ABS DEP ACT  DEPEND ERR
  16    14   0   14       1   0   0    1         ON      0.82380E+02 0.40000E+02 0.11500E+03 0.0         0.34418E+03 0.63232E-01
  17    15   0    6       1   0   0    4         ON      0.22524E+04 0.12000E+04 0.40000E+04 0.20000E+03 0.99996E+02-0.83923E-02
  19    18   0   10       1   0   0    7         OFF     0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0
  20    15   0   10       1   0   0    5         OFF     0.0         0.10000E+00 0.30000E+01 0.20000E+03 0.0         0.0
  21    15   0    1       1   0   0    1         OFF     0.0         0.50000E+00 0.10000E+02 0.30000E+03 0.0         0.0
  22    11   0   11       2   0   0    3         OFF     0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
  23    12   0   12       2   0   0    3         OFF     0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
  25    24   0   10       1   0   0    7         OFF     0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0

SCHED      REFERENCE NOS.             VARIABLE NOS.
      SCHDVAR    ARG1     ARG2     SCHDVAR      ARG1     ARG2
      CPT  STA CPT  STA CPT  STA  DAT  VAR  STA VAR  STA VAR  STA  SCHDVAR ACT SCHDVAR TBL  ARG1 ACT    ARG1 TBL    ARG2 ACT    ARG2 TBL
  18   10   0   0   11   0    0    0    8    0   0    1   0    0   0.81700E+00 0.88000E+00 0.21537E+01 0.21537E+01 0.0         0.0
  24   10   0  15    0   0    0    0    8    0   1    0   0    0   0.81700E+00 0.81700E+00 0.19999E+03 0.19999E+03 0.0         0.0

                 OVERALL ENGINE PERFORMANCE DATA

          AIR,LB/SEC   FUEL,LB/HR   GRS.JET THT  NET JET THT  PROP.THRUST *TOT.NET THT  FUEL/TOTTHT  TOTTHT/AIR  OVERBRD BLEED
          0.21473E+01  0.10039E+03  0.11674E+02  0.11674E+02  0.0          0.11674E+02  0.85996E+01  0.54366E+01  0.21473E-01

          BRAKE SH.HP  PROP. HP    *TOT.SHFT HP  FUEL/TOTSHP  TOTSHP/AIR   EQUIV.SH.HP  FUEL/ESHP    ESHP/AIR
          0.19999E+03  0.0          0.19999E+03  0.50199E+00  0.93135E+02  0.19999E+03  0.50199E+00  0.93135E+02
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98 REGENERATIVE PROPOSAL ENGINE OFF-DES 1/29/80 POINT R5J

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
1	0.23152E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.35879E+01	0.0	0.0
2	0.23152E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.35879E+01	0.0	0.0
3	0.21207E+01	0.10783E+03	0.10199E+04	0.19663E+01	0.0	0.62811E+00	0.0	0.0
4	0.19448E+00	0.0	0.10199E+04	0.19663E+01	0.0	0.0	0.0	0.0
5	0.21207E+01	0.10568E+03	0.10199E+04	0.19663E+01	0.0	0.64090E+00	0.0	0.0
6	0.21206E+01	0.10568E+03	0.14280E+04	0.27530E+01	0.0	0.75832E+00	0.0	0.0
7	0.21206E+01	0.10354E+03	0.14280E+04	0.27530E+01	0.0	0.77393E+00	0.0	0.0
8	0.21551E+01	0.99920E+02	0.24219E+04	0.46693E+01	0.16160E-01	0.10614E+01	0.0	0.0
9	0.22246E+01	0.99920E+02	0.23817E+04	0.45918E+01	0.15648E-01	0.10865E+01	0.0	0.0
10	0.23264E+01	0.36036E+02	0.19016E+04	0.36661E+01	0.14953E-01	0.28152E+01	0.0	0.0
11	0.23264E+01	0.36036E+02	0.19016E+04	0.36661E+01	0.14953E-01	0.28152E+01	0.0	0.0
12	0.23264E+01	0.15620E+02	0.15994E+04	0.30835E+01	0.14953E-01	0.59562E+01	0.0	0.0
13	0.23265E+01	0.15146E+02	0.15994E+04	0.30835E+01	0.14953E-01	0.61429E+01	0.0	0.0
14	0.23265E+01	0.15146E+02	0.12442E+04	0.23987E+01	0.14953E-01	0.54180E+01	0.0	0.0
15	0.23253E+01	0.14834E+02	0.12442E+04	0.23987E+01	0.14953E-01	0.55292E+01	0.12631E+00	0.14696E+02
16	0.23253E+01	0.14831E+02	0.12442E+04	0.23987E+01	0.14953E-01	0.55303E+01	0.12505E+00	0.14696E+02

275 hp

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.39963E+03	0.83948E+02	0.73373E+01	0.78173E+00	0.84000E-01	0.13960E+01	0.47850E+05	0.75265E+01	0.32862E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.19969E-01	0.0	0.0	0.50617E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.20171E-01	0.0	0.0	0.35077E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.35714E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.30371E-01	0.0	0.0	0.85609E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.20586E-01	0.0	0.0	0.70128E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.24219E+04	0.99393E+03	0.35000E-01	0.12337E+03	0.99000E+00	0.0	0.11129E+07	0.24016E+06	0.15291E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.40168E+03	0.83948E+02	0.27728E+01	0.86500E+00	0.52381E+00	0.0	0.99336E+00	0.27728E+01	0.35630E+01
10	11 4 12 0	0.27633E+03	0.20000E+05	0.23070E+01	0.85400E+00	0.0	0.0	0.10043E+01	0.23070E+01	0.35630E+01

HT EX	STATIONS	JP1 TEMP	JP2 TEMP	JM1 CORFLO	JM2 CORFLO	JM1 DELP/PT	JM2 DELP/PT	EFFECTVNESS	EFFT SCL F.	LIMIT IND
4	5 13 6 14	0.14280E+04	0.12442E+04	0.64090E+00	0.61429E+01	0.0	0.0	0.70420E+00	0.70420E+00	0.0

NOZZL	STATIONS	GRSS THRUST	NOZZLE AREA	ACT JET VEL	IDL JET VEL	IDL VEL PR	PTIN/PAMB	DISCHG COEF	VEL COEF	NOZZLE TYPE
13	15 0 16 0	0.14179E+02	0.52900E+02	0.19617E+03	0.19815E+03	0.10094E+01	0.10094E+01	0.10000E+01	0.99000E+00	CONV

SHAFT	COMPONENTS	NET HP	ACTUAL RPM	JM1 MCH EFF	JM2 MCH EFF	JP1 MCH EFF	JP2 MCH EFF	TORQUE	NON-TURB HP	SUM ABS HP/2
14	8 0 2 0	0.33691E-01	0.83948E+02	0.99500E+00	0.0	0.10000E+01	0.0	0.21079E+01	-0.39963E+03	0.39965E+03
15	10 0 0 0	0.27495E+03	0.20000E+05	0.99500E+00	0.0	0.0	0.0	0.72203E+02	0.0	0.13747E+03

CONTR	REFERENCE NOS. DEPEND CPT	DEPEND STA	INDEP CPT	VARIABLE NOS. DEPEND VAR	DEPEND STA	DEPEND PER	INDEP DAT	CONTR SWITCH	INDEP VAR	MIN LIMIT	MAX LIMIT	DEPEND DES	ABS DEP ACT	DEPEND ERR
16	14	0	14	1	0	0	1	ON	0.83948E+02	0.40000E+02	0.11500E+03	0.0	0.39965E+03	0.33691E-01
17	15	0	6	1	0	0	4	OFF	0.0	0.12000E+04	0.40000E+04	0.27500E+03	0.0	0.0
19	18	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0
20	15	0	10	1	0	0	5	ON	0.79012E+00	0.10000E+00	0.30000E+01	0.27500E+03	0.13747E+03	-0.51270E-01
21	15	0	1	1	0	0	1	OFF	0.0	0.50000E+00	0.10000E+02	0.30000E+03	0.0	0.0
22	11	0	11	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
23	12	0	12	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
25	24	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0

SCHED	REFERENCE NOS. SCHDVAR CPT	SCHDVAR STA	ARG1 CPT	ARG1 STA	ARG2 CPT	ARG2 STA	VARIABLE NOS. SCHDVAR DAT	SCHDVAR VAR	SCHDVAR STA	ARG1 VAR	ARG1 STA	ARG2 VAR	ARG2 STA	SCHDVAR ACT	SCHDVAR TBL	ARG1 ACT	ARG1 TBL	ARG2 ACT	ARG2 TBL
18	10	0	0	11	0	0	0	8	0	0	1	0	0	0.85400E+00	0.88000E+00	0.23264E+01	0.23264E+01	0.0	0.0
24	10	0	15	0	0	0	0	8	0	1	0	0	0	0.85400E+00	0.85399E+00	0.27495E+03	0.27495E+03	0.0	0.0

OVERALL ENGINE PERFORMANCE DATA

AIR,LB/SEC	FUEL,LB/HR	GRS.JET THT	NET JET THT	PROP.THRUST	*TOT.NET THT	FUEL/TOTTHT	TOTTHT/AIR	OVERBRD BLEED
0.23152E+01	0.12337E+03	0.14179E+02	0.14179E+02	0.0	0.14179E+02	0.87014E+01	0.61241E+01	0.23152E-01

BRAKE SH.HP	PROP. HP	*TOT.SHFT HP	FUEL/TOTSHP	TOTSHP/AIR	EQUIV.SH.HP	FUEL/ESHP	ESHP/AIR
0.27495E+03	0.0	0.27495E+03	0.44872E+00	0.11876E+03	0.27495E+03	0.44872E+00	0.11876E+03

98 REGENERATIVE PROPOSAL ENGINE DES PT 1/29/80 POINT R5J

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

	STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
	1	0.24151E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.37427E+01	0.0	0.0
	2	0.24151E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.37427E+01	0.0	0.0
	3	0.22122E+01	0.11316E+03	0.10338E+04	0.19931E+01	0.0	0.62858E+00	0.0	0.0
	4	0.20287E+00	0.0	0.10338E+04	0.19931E+01	0.0	0.0	0.0	0.0
	5	0.22122E+01	0.11090E+03	0.10338E+04	0.19931E+01	0.0	0.64141E+00	0.0	0.0
	6	0.22122E+01	0.11090E+03	0.14328E+04	0.27624E+01	0.0	0.75511E+00	0.0	0.0
	7	0.22122E+01	0.10868E+03	0.14328E+04	0.27624E+01	0.0	0.77052E+00	0.0	0.0
4.0	8	0.22489E+01	0.10487E+03	0.24500E+04	0.47234E+01	0.16583E-01	0.10614E+01	0.0	0.0
4.1	9	0.23214E+01	0.10487E+03	0.24095E+04	0.46453E+01	0.16057E-01	0.10865E+01	0.0	0.0
	10	0.24277E+01	0.37123E+02	0.19179E+04	0.36975E+01	0.15344E-01	0.28638E+01	0.0	0.0
	11	0.24277E+01	0.37123E+02	0.19179E+04	0.36975E+01	0.15344E-01	0.28638E+01	0.0	0.0
4.5	12	0.24276E+01	0.15700E+02	0.16024E+04	0.30894E+01	0.15344E-01	0.61898E+01	0.0	0.0
	13	0.24276E+01	0.15185E+02	0.16024E+04	0.30894E+01	0.15344E-01	0.63997E+01	0.0	0.0
	14	0.24276E+01	0.15185E+02	0.12554E+04	0.24202E+01	0.15344E-01	0.56643E+01	0.0	0.0
	15	0.24278E+01	0.14843E+02	0.12554E+04	0.24202E+01	0.15344E-01	0.57953E+01	0.13248E+00	0.14696E+02
	16	0.24278E+01	0.14840E+02	0.12554E+04	0.24202E+01	0.15344E-01	0.57965E+01	0.13115E+00	0.14696E+02

300 hp
60% IRP

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.42872E+03	0.85000E+02	0.77000E+01	0.78416E+00	0.84000E-01	0.14000E+01	0.48450E+05	0.79000E+01	0.34280E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.20000E-01	0.0	0.0	0.50617E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.20001E-01	0.0	0.0	0.35077E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.35714E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.32800E-01	0.0	0.0	0.85609E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.22500E-01	0.0	0.0	0.70128E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LOG 1	COMB LOG 2	COMB LOG 3
6	7 0 8 0	0.24500E+04	0.10172E+04	0.35000E-01	0.13207E+03	0.99000E+00	0.0	0.11351E+07	0.23564E+06	0.14480E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.43088E+03	0.85000E+02	0.28250E+01	0.86500E+00	0.52381E+00	0.0	0.10000E+01	0.28250E+01	0.35630E+01
10	11 4 12 0	0.30150E+03	0.20000E+05	0.23646E+01	0.86200E+00	0.0	0.0	0.10000E+01	0.23646E+01	0.35630E+01

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HT EX  STATIONS     JP1 TEMP    JP2 TEMP    JM1 CORFLO  JM2 CORFLO JM1 DELP/PT JM2 DELP/PT EFFECTVNESS EFFT SCL F.  LIMIT IND
  4   5 13  6 14   0.14328E+04 0.12554E+04 0.64141E+00 0.63997E+01 0.0         0.0         0.70170E+00 0.70170E+00 0.0

NOZZL  STATIONS    GRSS THRUST NOZZLE AREA ACT JET VEL IDL JET VEL IDL VEL PR   PTIN/PAMB  DISCHG COEF  VEL COEF   NOZZLE TYPE
 13  15  0 16  0   0.15591E+02 0.52900E+02 0.20662E+03 0.20870E+03 0.10100E+01 0.10100E+01 0.10000E+01 0.99000E+00    CONV

SHAFT COMPONENTS     NET HP     ACTUAL RPM JM1 MCH EFF JM2 MCH EFF JP1 MCH EFF JP2 MCH EFF   TORQUE    NON-TURB HP SUM ABS HP/2
 14   8  0  2  0   0.48828E-02 0.85000E+02 0.99500E+00 0.0         0.10000E+01 0.0         0.30171E+00-0.42872E+03 0.42873E+03
 15  10  0  0  0   0.29999E+03 0.20000E+05 0.99500E+00 0.0         0.0         0.0         0.78779E+02 0.0         0.15000E+03

CONTR  REFERENCE NOS.    VARIABLE NOS.
       DEPEND  INDEP     DEPEND    INDEP
       CPT STA  CPT    VAR STA PER  DAT   CONTR SWITCH  INDEP VAR   MIN LIMIT   MAX LIMIT   DEPEND DES ABS DEP ACT  DEPEND ERR
 16     14   0   14     1   0   0    1        ON       0.85000E+02 0.40000E+02 0.11500E+03 0.0         0.42873E+03 0.48828E-02
 17     15   0    6     1   0   0    4        OFF      0.0         0.12000E+04 0.40000E+04 0.20000E+03 0.0         0.0
 19     18   0   10     1   0   0    7        OFF      0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0
 20     15   0   10     1   0   0    5        OFF      0.0         0.10000E+00 0.30000E+01 0.30000E+03 0.0         0.0
 21     15   0    1     1   0   0    1        OFF      0.0         0.50000E+00 0.10000E+02 0.30000E+03 0.0         0.0
 22     11   0   11     2   0   0    3        OFF      0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
 23     12   0   12     2   0   0    3        OFF      0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
 25     24   0   10     1   0   0    7        OFF      0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0

SCHED     REFERENCE NOS.              VARIABLE NOS.
      SCHDVAR   ARG1    ARG2      SCHDVAR     ARG1    ARG2
      CPT STA CPT STA CPT STA   DAT VAR STA VAR STA VAR STA  SCHDVAR ACT SCHDVAR TBL  ARG1 ACT    ARG1 TBL    ARG2 ACT    ARG2 TBL
 18   10   0   0  11   0   0     0   8   0   0   1   0   0  0.86200E+00 0.88000E+00 0.24277E+01 0.24277E+01 0.0         0.0
 24   10   0  15   0   0   0     0   8   0   1   0   0   0  0.86200E+00 0.86200E+00 0.29999E+03 0.29999E+03 0.0         0.0

               OVERALL ENGINE PERFORMANCE DATA

            AIR,LB/SEC   FUEL,LB/HR   GRS.JET THT  NET JET THT  PROP.THRUST *TOT.NET THT  FUEL/TOTTHT  TOTTHT/AIR  OVERBRD BLEED
             0.24151E+01  0.13207E+03  0.15591E+02  0.15591E+02  0.0          0.15591E+02  0.84708E+01  0.64557E+01  0.24151E-01

            BRAKE SH.HP  PROP. HP    *TOT.SHFT HP  FUEL/TOTSHP  TOTSHP/AIR   EQUIV.SH.HP  FUEL/ESHP    ESHP/AIR
             0.29999E+03  0.0          0.29999E+03  0.44025E+00  0.12421E+03  0.29999E+03  0.44025E+00  0.12421E+03
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98 REGENERATIVE PROPOSAL ENGINE OFF-DES 1/29/80 POINT R5J

COMPONENT PERFORMANCE DATA — COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT — COMPONENT ERROR SIGNAL = 0

STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
1	0.26893E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.41677E+01	0.0	0.0
2	0.26893E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.41677E+01	0.0	0.0
3	0.24634E+01	0.12826E+03	0.10712E+04	0.20652E+01	0.0	0.62862E+00	0.0	0.0
4	0.22590E+00	0.0	0.10712E+04	0.20652E+01	0.0	0.0	0.0	0.0
5	0.24634E+01	0.12569E+03	0.10712E+04	0.20652E+01	0.0	0.64145E+00	0.0	0.0
6	0.24635E+01	0.12569E+03	0.14516E+04	0.27985E+01	0.0	0.74672E+00	0.0	0.0
7	0.24635E+01	0.12324E+03	0.14516E+04	0.27985E+01	0.0	0.76162E+00	0.0	0.0
8	0.25074E+01	0.11892E+03	0.25344E+04	0.48862E+01	0.17797E-01	0.10614E+01	0.0	0.0
9	0.25880E+01	0.11892E+03	0.24926E+04	0.48057E+01	0.17233E-01	0.10865E+01	0.0	0.0
10	0.27064E+01	0.40310E+02	0.19705E+04	0.37990E+01	0.16467E-01	0.29803E+01	0.0	0.0
11	0.27064E+01	0.40310E+02	0.19705E+04	0.37990E+01	0.16467E-01	0.29803E+01	0.0	0.0
12	0.27064E+01	0.15957E+02	0.16188E+04	0.31209E+01	0.16467E-01	0.68237E+01	0.0	0.0
13	0.27064E+01	0.15321E+02	0.16188E+04	0.31209E+01	0.16467E-01	0.71070E+01	0.0	0.0
14	0.27064E+01	0.15321E+02	0.12887E+04	0.24846E+01	0.16467E-01	0.63414E+01	0.0	0.0
15	0.27095E+01	0.14889E+02	0.12887E+04	0.24846E+01	0.16467E-01	0.65329E+01	0.14972E+00	0.14696E+02
16	0.27095E+01	0.14885E+02	0.12887E+04	0.24846E+01	0.16467E-01	0.65346E+01	0.14822E+00	0.14696E+02

375 hp

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.51302E+03	0.87521E+02	0.87275E+01	0.78978E+00	0.84000E-01	0.14426E+01	0.49887E+05	0.89582E+01	0.38172E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.20002E-01	0.0	0.0	0.50617E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.19559E-01	0.0	0.0	0.35077E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.35714E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.39862E-01	0.0	0.0	0.85609E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.28201E-01	0.0	0.0	0.70128E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.25344E+04	0.10828E+04	0.35000E-01	0.15784E+03	0.99000E+00	0.0	0.11963E+07	0.22459E+06	0.12540E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.51560E+03	0.87521E+02	0.29502E+01	0.86500E+00	0.52381E+00	0.0	0.10123E+01	0.29502E+01	0.35630E+01
10	11 4 12 0	0.37671E+03	0.20000E+05	0.25261E+01	0.88000E+00	0.0	0.0	0.98655E+00	0.25261E+01	0.35630E+01

HT EX	STATIONS	JP1 TEMP	JP2 TEMP	JM1 CORFLO	JM2 CORFLO	JM1 DELP/PT	JM2 DELP/PT	EFFECTVNESS	EFFT SCL F.	LIMIT IND
4	5 13 6 14	0.14518E+04	0.12885E+04	0.64145E+00	0.71070E+01	0.0	0.0	0.69510E+00	0.69510E+00	0.0

NOZZL	STATIONS	GRSS THRUST	NOZZLE AREA	ACT JET VEL	IDL JET VEL	IDL VEL PR	PTIN/PAMB	DISCHG COEF	VEL COEF	NOZZLE TYPE
13	15 0 16 0	0.19922E+02	0.52900E+02	0.23655E+03	0.23894E+03	0.10131E+01	0.10131E+01	0.10000E+01	0.99000E+00	CONV

SHAFT	COMPONENTS	NET HP	ACTUAL RPM	JM1 MCH EFF	JM2 MCH EFF	JP1 MCH EFF	JP2 MCH EFF	TORQUE	NON-TURB HP	SUM ABS HP/2
14	8 0 2 0	0.36621E-02	0.87521E+02	0.99500E+00	0.0	0.10000E+01	0.0	0.21976E+00	-0.51302E+03	0.51302E+03
15	10 0 0 0	0.37482E+03	0.20000E+05	0.99500E+00	0.0	0.0	0.0	0.98430E+02	0.0	0.18741E+03

CONTR	REFERENCE NOS.			VARIABLE NOS.										
	DEPEND		INDEP	DEPEND			INDEP							
	CPT	STA	CPT	VAR	STA	PER	DAT	CONTR SWITCH	INDEP VAR	MIN LIMIT	MAX LIMIT	DEPEND DES	ABS DEP ACT	DEPEND ERR
16	14	0	14	1	0	0	1	ON	0.87521E+02	0.40000E+02	0.11500E+03	0.0	0.51302E+03	0.36621E-02
17	15	0	6	1	0	0	4	OFF	0.0	0.12000E+04	0.40000E+04	0.37500E+03	0.0	0.0
19	18	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0
20	15	0	10	1	0	0	5	ON	0.83647E+00	0.10000E+00	0.30000E+01	0.37500E+03	0.18741E+03	-0.17773E+00
21	15	0	1	1	0	0	1	OFF	0.0	0.50000E+00	0.10000E+02	0.30000E+03	0.0	0.0
22	11	[illegible]	11	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
23	12	0	[illegible]	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
25	24	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0

SCHED	REFERENCE NOS.						VARIABLE NOS.												
	SCHDVAR		ARG1		ARG2		SCHDVAR			ARG1		ARG2							
	CPT	STA	CPT	STA	CPT	STA	DAT	VAR	STA	VAR	STA	VAR	STA	SCHDVAR ACT	SCHDVAR TBL	ARG1 ACT	ARG1 TBL	ARG2 ACT	ARG2 TBL
18	10	0	0	11	0	0	0	8	0	0	1	0	0	0.88000E+00	0.88000E+00	0.27064E+01	0.27064E+01	0.0	0.0
24	10	0	15	0	0	0	0	8	0	1	0	0	0	0.88000E+00	0.87996E+00	0.37482E+03	0.37482E+03	0.0	0.0

OVERALL ENGINE PERFORMANCE DATA

AIR,LB/SEC	FUEL,LB/HR	GRS.JET THT	NET JET THT	PROP.THRUST	*TOT.NET THT	FUEL/TOTTHT	TOTTHT/AIR	OVERBRD BLEED
0.26893E+01	0.15784E+03	0.19922E+02	0.19922E+02	0.0	0.19922E+02	0.79230E+01	0.74076E+01	0.26893E-01

BRAKE SH.HP	PROP. HP	*TOT.SHFT HP	FUEL/TOTSHP	TOTSHP/AIR	EQUIV.SH.HP	FUEL/ESHP	ESHP/AIR
0.37482E+03	0.0	0.37482E+03	0.42110E+00	0.13937E+03	0.37482E+03	0.42110E+00	0.13937E+03

98 REGENERATIVE PROPOSAL ENGINE OFF-DES 1/29/80 POINT R5J

COMPONENT PERFORMANCE DATA — COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT — COMPONENT ERROR SIGNAL = 0

	STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
	1	0.33497E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.51911E+01	0.0	0.0
	2	0.33497E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.51911E+01	0.0	0.0
	3	0.30681E+01	0.16444E+03	0.11665E+04	0.22489E+01	0.0	0.63726E+00	0.0	0.0
	4	0.28138E+00	0.0	0.11665E+04	0.22489E+01	0.0	0.0	0.0	0.0
	5	0.30681E+01	0.16106E+03	0.11665E+04	0.22489E+01	0.0	0.65063E+00	0.0	0.0
	6	0.30683E+01	0.16106E+03	0.15021E+04	0.28960E+01	0.0	0.73836E+00	0.0	0.0
	7	0.30683E+01	0.15798E+03	0.15021E+04	0.28960E+01	0.0	0.75276E+00	0.0	0.0
4.0	8	0.31281E+01	0.15245E+03	0.26750E+04	0.51572E+01	0.19552E-01	0.10613E+01	0.0	0.0
4.1	9	0.32286E+01	0.15245E+03	0.26320E+04	0.50743E+01	0.18932E-01	0.10865E+01	0.0	0.0
	10	0.33760E+01	0.44919E+02	0.20316E+04	0.39168E+01	0.18091E-01	0.33876E+01	0.0	0.0
	11	0.33760E+01	0.44919E+02	0.20316E+04	0.39168E+01	0.18091E-01	0.33876E+01	0.0	0.0
4.5	12	0.33760E+01	0.16674E+02	0.16583E+04	0.31971E+01	0.18091E-01	0.82450E+01	0.0	0.0
	13	0.33760E+01	0.15704E+02	0.16583E+04	0.31971E+01	0.18091E-01	0.87547E+01	0.0	0.0
	14	0.33757E+01	0.15704E+02	0.13677E+04	0.26368E+01	0.18091E-01	0.79499E+01	0.0	0.0
	15	0.33686E+01	0.15007E+02	0.13677E+04	0.26368E+01	0.18091E-01	0.83012E+01	0.19159E+00	0.14696E+02
	16	0.33686E+01	0.15001E+02	0.13677E+04	0.26368E+01	0.18091E-01	0.83047E+01	0.18967E+00	0.14696E+02

500 hp
IRP

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.75287E+03	0.94845E+02	0.11189E+02	0.77656E+00	0.84000E-01	0.15980E+01	0.54062E+05	0.11493E+02	0.47546E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.20556E-01	0.0	0.0	0.50617E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.19123E-01	0.0	0.0	0.35077E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.35714E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.58197E-01	0.0	0.0	0.85609E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.44322E-01	0.0	0.0	0.70128E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LOG 3
6	7 0 8 0	0.26750E+04	0.11729E+04	0.35000E-01	0.21597E+03	0.99000E+00	0.0	0.12769E+07	0.19653E+06	0.95045E-01

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE COPFLO
8	9 4 10 0	0.75639E+03	0.94845E+02	0.33939E+01	0.86500E+00	0.52381E+00	0.0	0.10676E+01	0.33939E+01	0.35630E+01
10	11 4 12 0	0.50253E+03	0.20000E+05	0.26939E+01	0.85900E+00	0.0	0.0	0.97160E+00	0.26939E+01	0.35630E+01

```
HT EX  STATIONS     JP1 TEMP    JP2 TEMP    JM1 CORFLO  JM2 CORFLO JM1 DELP/PT JM2 DELP/PT EFFECTVNESS EFFT SCL F.  LIMIT IND
  4   5 13  6 14   0.15021E+04 0.13677E+04 0.65063E+00 0.87547E+01 0.0         0.0         0.68250E+00 0.68250E+00 0.0

NOZZL  STATIONS    GRSS THRUST NOZZLE AREA ACT JET VEL IDL JET VEL IDL VEL PR   PTIN/PAMB  DISCHG COEF  VEL COEF   NOZZLE TYPE
 13  15  0 16  0   0.32614E+02 0.52900E+02 0.31149E+03 0.31464E+03 0.10212E+01 0.10212E+01 0.10000E+01 0.99000E+00    CONV

SHAFT COMPONENTS      NET HP     ACTUAL RPM JM1 MCH EFF JM2 MCH EFF JP1 MCH EFF JP2 MCH EFF    TORQUE     NON-TURB HP SUM ABS HP/2
 14   8  0  2  0  -0.26660E+00 0.94845E+02 0.99500E+00 0.0         0.10000E+01 0.0        -0.14763E+02-0.75287E+03 0.75274E+03
 15  10  0  0  0   0.50002E+03 0.20000E+05 0.99500E+00 0.0         0.0         0.0         0.13131E+03 0.0         0.25001E+03

CONTR  REFERENCE NOS.    VARIABLE NOS.
       DEPEND  INDEP       DEPEND     INDEP
       CPT STA  CPT     VAR STA PER  DAT    CONTR SWITCH  INDEP VAR    MIN LIMIT   MAX LIMIT   DEPEND DES ABS DEP ACT  DEPEND ERR
 16     14   0   14       1   0   0    1         ON      0.94845E+02 0.40000E+02 0.11500E+03 0.0         0.75274E+03-0.26660E+00
 17     15   0    6       1   0   0    4         OFF     0.0         0.12000E+04 0.40000E+04 0.50000E+03 0.0         0.0
 19     18   0   10       1   0   0    7         OFF     0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0
 20     15   0   10       1   0   0    5         ON      0.95077E+00 0.10000E+00 0.30000E+01 0.50000E+03 0.25001E+03 0.21973E-01
 21     15   0    1       1   0   0    1         OFF     0.0         0.50000E+00 0.10000E+02 0.30000E+03 0.0         0.0
 22     11   0   11       2   0   0    3         OFF     0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
 23     12   0   12       2   0   0    3         OFF     0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
 25     24   0   10       1   0   0    7         OFF     0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0

SCHED      REFERENCE NOS.                VARIABLE NOS.
      SCHDVAR   ARG1    ARG2      SCHDVAR     ARG1     ARG2
      CPT STA CPT STA CPT STA   DAT VAR STA VAR STA VAR STA   SCHDVAR ACT SCHDVAR TBL  ARG1 ACT    ARG1 TBL    ARG2 ACT    ARG2 TBL
 18   10   0   0  11   0   0     0   8   0   0   1   0   0   0.85900E+00 0.88000E+00 0.33760E+01 0.33760E+01 0.0         0.0
 24   10   0  15   0   0   0     0   8   0   1   0   0   0   0.85900E+00 0.85900E+00 0.50002E+03 0.50002E+03 0.0         0.0

                        OVERALL ENGINE PERFORMANCE DATA

                  AIR,LB/SEC   FUEL,LB/HR   GRS.JET THT  NET JET THT  PROP.THRUST *TOT.NET THT  FUEL/TOTTHT  TOTTHT/AIR  OVERBRD BLEED
                   0.33497E+01  0.21597E+03  0.32614E+02  0.32614E+02  0.0          0.32614E+02  0.66219E+01  0.97364E+01  0.33497E-01

                  BRAKE SH.HP  PROP. HP    *TOT.SHFT HP  FUEL/TOTSHP  TOTSHP/AIR   EQUIV.SH.HP  FUEL/ESHP    ESHP/AIR
                   0.50002E+03  0.0          0.50002E+03  0.43192E+00  0.14927E+03  0.50002E+03  0.43192E+00  0.14927E+03
```

APPENDIX B: CYCLE 5 RECUPERATOR DATA

CD = 22.2 in.

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=R5 ,E/D=.105 ,GFLO=2.5CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	6.00	XID	17.20	N	3300.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	12.61	XMD	19.70	AS	64.79	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	0.66	XOD	22.20	FAR	8.00										
E	0.6252	PDT	1.67	WT1	2.225	P1T	7.621	P2T	7.49	T1T	573.8	RET	6635.2	HT	135.5
CC	0.8752	PDS	3.29	WS1	2.461	P1S	1.055	P2S	1.02	T1S	1139.0	RES	764.4	HS	86.9
CMIN	TUBE	PD	4.96	NTU	1.643			T2T	927.2	T2S	829.7	UA	3356.3	U	51.8

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=R5 ,E/D=.105 ,GFLO=2.5CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	8.00	XID	17.20	N	3300.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	16.03	XMD	19.70	AS	86.39	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	0.84	XOD	22.20	FAR	10.67										
E	0.6625	PDT	2.20	WT1	2.225	P1T	7.621	P2T	7.45	T1T	573.8	RET	6594.8	HT	136.0
CC	0.8773	PDS	1.97	WS1	2.461	P1S	1.040	P2S	1.02	T1S	1139.0	RES	576.2	HS	72.9
CMIN	TUBE	PD	4.17	NTU	1.965			T2T	948.2	T2S	810.5	UA	4021.0	U	46.5

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=R5 ,E/D=.105 ,GFLO=2.5CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	10.00	XID	17.20	N	3300.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	19.45	XMD	19.70	AS	107.99	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.02	XOD	22.20	FAR	13.33										
E	0.6879	PDT	2.74	WT1	2.225	P1T	7.621	P2T	7.41	T1T	573.8	RET	6567.8	HT	136.3
CC	0.8788	PDS	1.31	WS1	2.461	P1S	1.034	P2S	1.02	T1S	1139.0	RES	462.5	HS	63.6
CMIN	TUBE	PD	4.05	NTU	2.248			T2T	962.5	T2S	797.3	UA	4602.7	U	42.6

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=R5 ,E/D=.105 ,GFLO=2.5CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	12.00	XID	17.20	N	3300.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	22.87	XMD	19.70	AS	129.59	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.20	XOD	22.20	FAR	16.00										
E	0.7065	PDT	3.27	WT1	2.225	P1T	7.621	P2T	7.37	T1T	573.8	RET	6547.6	HT	136.5
CC	0.8799	PDS	0.94	WS1	2.461	P1S	1.030	P2S	1.02	T1S	1139.0	RES	386.4	HS	57.0
CMIN	TUBE	PD	4.22	NTU	2.500			T2T	973.2	T2S	787.6	UA	5124.1	U	39.5

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=R5 ,E/D=.105 ,GFLO=2.5CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	14.00	XID	17.20	N	3300.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01163	SIGT	0.5630
WGT	26.29	XMD	19.70	AS	151.18	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.38	XOD	22.20	FAR	18.67										
E	0.7206	PDT	3.81	WT1	2.225	P1T	7.621	P2T	7.33	T1T	573.8	RET	6532.7	HT	136.7
CC	0.8007	PDS	0.71	WS1	2.461	P1S	1.027	P2S	1.02	T1S	1139.0	RES	331.8	HS	51.9
CMIN	TUBE	PD	4.53	NTU	2.731			T2T	981.1	T2S	780.3	UA	5599.1	U	37.0

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=R5 ,E/D=.105 ,GFLO=2.5CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	16.00	XID	17.20	N	3300.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	29.71	XMD	19.70	AS	172.78	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.56	XOD	22.20	FAR	21.33										
E	0.7318	PDT	4.36	WT1	2.225	P1T	7.621	P2T	7.29	T1T	573.8	RET	6521.0	HT	136.8
CC	0.8814	PDS	0.56	WS1	2.461	P1S	1.026	P2S	1.02	T1S	1139.0	RES	290.8	HS	47.8
CMIN	TUBE	PD	4.92	NTU	2.943			T2T	987.4	T2S	774.4	UA	6037.4	U	34.9

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=R5 ,E/D=.105 ,GFLO=2.5CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	18.00	XID	17.20	N	3300.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	33.13	XMD	19.70	AS	194.38	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.73	XOD	22.20	FAR	24.00										
E	0.7408	PDT	4.91	WT1	2.225	P1T	7.621	P2T	7.25	T1T	573.8	RET	6511.5	HT	136.9
CC	0.8819	PDS	0.45	WS1	2.461	P1S	1.025	P2S	1.02	T1S	1139.0	RES	258.8	HS	44.6
CMIN	TUBE	PD	5.36	NTU	3.141			T2T	992.5	T2S	769.7	UA	6445.4	U	33.2

APPENDIX C: SELECTED CYCLE DATA

98 REGENERATIVE PROPOSAL ENGINE OFF-DES 2/21/80 POINT FI16

COMPONENT PERFORMANCE DATA   COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT   COMPONENT ERROR SIGNAL = 0

	STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
	1	0.15810E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.24501E+01	0.0	0.0
	2	0.15810E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.24501E+01	0.0	0.0
	3	0.14151E+01	0.65225E+02	0.87697E+03	0.16907E+01	0.0	0.64249E+00	0.0	0.0
	4	0.16600E+00	0.0	0.87697E+03	0.16907E+01	0.0	0.0	0.0	0.0
	5	0.14151E+01	0.64108E+02	0.87697E+03	0.16907E+01	0.0	0.65368E+00	0.0	0.0
	6	0.14151E+01	0.64108E+02	0.12849E+04	0.24772E+01	0.0	0.79124E+00	0.0	0.0
	7	0.14151E+01	0.63002E+02	0.12849E+04	0.24772E+01	0.0	0.80513E+00	0.0	0.0
4.0	8	0.14286E+01	0.60797E+02	0.19074E+04	0.36773E+01	0.95906E-02	0.10263E+01	0.0	0.0
4.1	9	0.14887E+01	0.60797E+02	0.18685E+04	0.36024E+01	0.92000E-02	0.10585E+01	0.0	0.0
	10	0.15783E+01	0.23743E+02	0.14952E+04	0.28827E+01	0.86704E-02	0.25713E+01	0.0	0.0
	11	0.15787E+01	0.23743E+02	0.14952E+04	0.28827E+01	0.86704E-02	0.25711E+01	0.0	0.0
4.5	12	0.15787E+01	0.15073E+02	0.14107E+04	0.27198E+01	0.86704E-02	0.39337E+01	0.0	0.0
	13	0.15787E+01	0.14877E+02	0.14107E+04	0.27198E+01	0.86704E-02	0.39858E+01	0.0	0.0
	14	0.15787E+01	0.14877E+02	0.10558E+04	0.20355E+01	0.86704E-02	0.34482E+01	0.0	0.0
	15	0.15644E+01	0.14753E+02	0.10558E+04	0.20355E+01	0.86704E-02	0.34457E+01	0.81908E-01	0.14696E+02
	16	0.15644E+01	0.14752E+02	0.10558E+04	0.20355E+01	0.86704E-02	0.34459E+01	0.81089E-01	0.14696E+02

50 hp
Uninstalled

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.19384E+03	0.75013E+02	0.44383E+01	0.76212E+00	0.10500E+00	0.15648E+01	0.42757E+05	0.47069E+01	0.23672E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.17121E-01	0.0	0.0	0.41475E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.17251E-01	0.0	0.0	0.27555E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.36190E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.13061E-01	0.0	0.0	0.84405E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.83255E-02	0.0	0.0	0.70022E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.19074E+04	0.62247E+03	0.35000E-01	0.48858E+02	0.99000E+00	0.0	0.72435E+06	0.23260E+06	0.27561E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.19483E+03	0.75013E+02	0.25606E+01	0.86300E+00	0.54286E+00	0.0	0.10136E+01	0.25606E+01	0.35630E+01
10	11 4 12 0	0.50260E+02	0.20000E+05	0.15752E+01	0.51300E+00	0.0	0.0	0.11472E+01	0.15752E+01	0.34281E+01

HT EX	STATIONS	JP1 TEMP	JP2 TEMP	JM1 CORFLO	JM2 CORFLO	JM1 DELP/PT	JM2 DELP/PT	EFFECTVNESS	EFFT SCL F.	LIMIT IND
4	5 13 6 14	0.12851E+04	0.10560E+04	0.65368E+00	0.39858E+01	0.0	0.0	0.76460E+00	0.76460E+00	0.0

NOZZL	STATIONS	GRSS THRUST	NOZZLE AREA	ACT JET VEL	IDL JET VEL	IDL VEL PR	PTIN/PAMB	DISCHG COEF	VEL COEF	NOZZLE TYPE
13	15 0 16 0	0.57131E+01	0.50472E+02	0.11749E+03	0.11867E+03	0.10039E+01	0.10039E+01	0.10000E+01	0.99000E+00	CONV

SHAFT	COMPONENTS	NET HP	ACTUAL RPM	JM1 MCH EFF	JM2 MCH EFF	JP1 MCH EFF	JP2 MCH EFF	TORQUE	NON-TURB HP	SUM ABS HP/2
14	8 0 2 0	0.23804E-01	0.75013E+02	0.99500E+00	0.0	0.10000E+01	0.0	0.16666E+01	-0.19384E+03	0.19385E+03
15	10 0 0 0	0.50008E+02	0.20000E+05	0.99500E+00	0.0	0.0	0.0	0.13132E+02	0.0	0.25004E+02

CONTR	REFERENCE NOS. DEPEND CPT	STA	INDEP CPT	VARIABLE NOS. DEPEND VAR	STA	PER	INDEP DAT	CONTR SWITCH	INDEP VAR	MIN LIMIT	MAX LIMIT	DEPEND DES	ABS DEP ACT	DEPEND ERR
16	14	0	14	1	0	0	1	ON	0.75013E+02	0.40000E+02	0.11500E+03	0.0	0.19385E+03	0.23804E-01
17	15	0	6	1	0	0	4	ON	0.19074E+04	0.12000E+04	0.40000E+04	0.50000E+02	0.25004E+02	0.82092E-02
19	18	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0
20	15	0	10	1	0	0	5	OFF	0.0	0.10000E+00	0.30000E+01	0.50000E+02	0.0	0.0
21	15	0	1	1	0	0	1	OFF	0.0	0.50000E+00	0.10000E+02	0.30000E+03	0.0	0.0
22	11	0	11	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
23	12	0	12	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
25	24	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0

SCHED	REFERENCE NOS. SCHDVAR CPT	STA	ARG1 CPT	STA	ARG2 CPT	STA	VARIABLE NOS. SCHDVAR DAT	VAR	STA	ARG1 VAR	STA	ARG2 VAR	STA	SCHDVAR ACT	SCHDVAR TBL	ARG1 ACT	ARG1 TBL	ARG2 ACT	ARG2 TBL
18	10	0	0	11	0	0	0	8	0	0	1	0	0	0.51300E+00	0.88000E+00	0.15787E+01	0.15787E+01	0.0	0.0
24	10	0	15	0	0	0	0	8	0	1	0	0	0	0.51300E+00	0.86000E+00	0.50008E+02	0.50008E+02	0.0	0.0

OVERALL ENGINE PERFORMANCE DATA

AIR,LB/SEC	FUEL,LB/HR	GRS.JET THT	NET JET THT	PROP.THRUST	*TOT.NET THT	FUEL/TOTTHT	TOTTHT/AIR	OVERBRD BLEED
0.15810E+01	0.48858E+02	0.57131E+01	0.57131E+01	0.0	0.57131E+01	0.85520E+01	0.36137E+01	0.15810E-01

BRAKE SH.HP	PROP. HP	*TOT.SHFT HP	FUEL/TOTSHP	TOTSHP/AIR	EQUIV.SH.HP	FUEL/ESHP	ESHP/AIR
0.50008E+02	0.0	0.50008E+02	0.97700E+00	0.31631E+02	0.50008E+02	0.97700E+00	0.31631E+02

98 REGENERATIVE PROPOSAL ENGINE OFF-DES 2/21/80 POINT FI16

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
1	0.20352E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.31540E+01	0.0	0.0
2	0.20353E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.31542E+01	0.0	0.0
3	0.18216E+01	0.92361E+02	0.96956E+03	0.18693E+01	0.0	0.61413E+00	0.0	0.0
4	0.21371E+00	0.0	0.96956E+03	0.18693E+01	0.0	0.0	0.0	0.0
5	0.18216E+01	0.90916E+02	0.96956E+03	0.18693E+01	0.0	0.62389E+00	0.0	0.0
6	0.18216E+01	0.90916E+02	0.14091E+04	0.27167E+01	0.0	0.75212E+00	0.0	0.0
7	0.18216E+01	0.89499E+02	0.14091E+04	0.27167E+01	0.0	0.76403E+00	0.0	0.0
8	0.16478E+01	0.86366E+02	0.23043E+04	0.44426E+01	0.14393E-01	0.10270E+01	0.0	0.0
9	0.19252E+01	0.86366E+02	0.22548E+04	0.43472E+01	0.13807E-01	0.10585E+01	0.0	0.0
10	0.20412E+01	0.32408E+02	0.18001E+04	0.34704E+01	0.13012E-01	0.26722E+01	0.0	0.0
11	0.20412E+01	0.32408E+02	0.18001E+04	0.34704E+01	0.13012E-01	0.26722E+01	0.0	0.0
12	0.20412E+01	0.15385E+02	0.15467E+04	0.29820E+01	0.13012E-01	0.52178E+01	0.0	0.0
13	0.20412E+01	0.15032E+02	0.15467E+04	0.29820E+01	0.13012E-01	0.53405E+01	0.0	0.0
14	0.20413E+01	0.15032E+02	0.11705E+04	0.22567E+01	0.13012E-01	0.46461E+01	0.0	0.0
15	0.20485E+01	0.14804E+02	0.11705E+04	0.22567E+01	0.13012E-01	0.47342E+01	0.11302E+00	0.14696E+02
16	0.20485E+01	0.14802E+02	0.11705E+04	0.22567E+01	0.13012E-01	0.47349E+01	0.11189E+00	0.14696E+02

200 hp
Uninstalled

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.31526E+03	0.82360E+02	0.62847E+01	0.78440E+00	0.10500E+00	0.15135E+01	0.46945E+05	0.66976E+01	0.30476E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.15643E-01	0.0	0.0	0.41475E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.15587E-01	0.0	0.0	0.27555E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.36190E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.22980E-01	0.0	0.0	0.84405E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.15115E-01	0.0	0.0	0.70022E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.23043E+04	0.89520E+03	0.35000E-01	0.94386E+02	0.99000E+00	0.0	0.98505E+06	0.23886E+06	0.17581E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.31686E+03	0.82360E+02	0.26650E+01	0.86300E+00	0.54286E+00	0.0	0.10131E+01	0.26650E+01	0.35630E+01
10	11 4 12 0	0.20100E+03	0.20000E+05	0.21065E+01	0.83100E+00	0.0	0.0	0.10455E+01	0.21065E+01	0.35630E+01

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HT EX  STATIONS     JP1 TEMP     JP2 TEMP     JM1 CORFLO   JM2 CORFLO  JM1 DELP/PT  JM2 DELP/PT EFFECTVNESS EFFT SCL F.  LIMIT IND
  4   5 13  6 14   0.14084E+04 0.11703E+04 0.62389E+00 0.53405E+01 0.0         0.0         0.76040E+00 0.76040E+00 0.0

NOZZL  STATIONS    GRSS THRUST NOZZLE AREA ACT JET VEL IDL JET VEL IDL VEL PR   PTIN/PAMB  DISCHG COEF  VEL COEF   NOZZLE TYPE
 13  15  0 16  0   0.10855E+02 0.50472E+02 0.17048E+03 0.17220E+03 0.10074E+01 0.10074E+01 0.10000E+01 0.99000E+00    CONV

SHAFT COMPONENTS      NET HP     ACTUAL RPM JM1 MCH EFF JM2 MCH EFF JP1 MCH EFF JP2 MCH EFF    TORQUE    NON-TURB HP SUM ABS HP/2
 14   8  0  2  0   0.73242E-02 0.82360E+02 0.99500E+00 0.0         0.10000E+01 0.0         0.46707E+00-0.31526E+03 0.31527E+03
 15  10  0  0  0   0.19999E+03 0.20000E+05 0.99500E+00 0.0         0.0         0.0         0.52520E+02 0.0         0.99997E+02

CONTR  REFERENCE NOS.    VARIABLE NOS.
       DEPEND  INDEP      DEPEND     INDEP
       CPT STA  CPT     VAR STA PER  DAT   CONTR SWITCH  INDEP VAR    MIN LIMIT   MAX LIMIT   DEPEND DES ABS DEP ACT  DEPEND ERR
 16     14  0   14       1   0   0    1        ON      0.82360E+02 0.40000E+02 0.11500E+03 0.0         0.31527E+03 0.73242E-02
 17     15  0    6       1   0   0    4        ON      0.23043E+04 0.12000E+04 0.40000E+04 0.20000E+03 0.99997E+02-0.57831E-02
 19     18  0   10       1   0   0    7        OFF     0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0
 20     15  0   10       1   0   0    5        OFF     0.0         0.10000E+00 0.30000E+01 0.20000E+03 0.0         0.0
 21     15  0    1       1   0   0    1        OFF     0.0         0.50000E+00 0.10000E+02 0.30000E+03 0.0         0.0
 22     11  0   11       2   0   0    3        OFF     0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
 23     12  0   12       2   0   0    3        OFF     0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
 25     24  0   10       1   0   0    7        OFF     0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0

SCHED     REFERENCE NOS.               VARIABLE NOS.
      SCHDVAR   ARG1    ARG2       SCHDVAR      ARG1    ARG2
      CPT STA CPT STA CPT STA    DAT VAR STA  VAR STA  VAR STA  SCHDVAR ACT SCHDVAR TBL  ARG1 ACT    ARG1 TBL    ARG2 ACT    ARG2 TBL
 18    10  0   0  11   0   0      0   8   0    0   1    0   0   0.83100E+00 0.88000E+00 0.20412E+01 0.20412E+01 0.0         0.0
 24    10  0  15   0   0   0      0   8   0    1   0    0   0   0.83100E+00 0.81700E+00 0.19999E+03 0.19999E+03 0.0         0.0

                 OVERALL ENGINE PERFORMANCE DATA

           AIR,LB/SEC   FUEL,LB/HR   GRS.JET THT  NET JET THT  PROP.THRUST *TOT.NET THT  FUEL/TOTTHT  TOTTHT/AIR  OVERBRD BLEED
           0.20353E+01  0.94386E+02  0.10855E+02  0.10855E+02  0.0          0.10855E+02  0.86953E+01  0.53332E+01  0.20353E-01

           BRAKE SH.HP  PROP. HP    *TOT.SHFT HP  FUEL/TOTSHP  TOTSHP/AIR   EQUIV.SH.HP  FUEL/ESHP    ESHP/AIR
           0.19999E+03  0.0          0.19999E+03  0.47194E+00  0.98261E+02  0.19999E+03  0.47194E+00  0.98261E+02
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98 REGENERATIVE PROPOSAL ENGINE OFF-DES 2/21/80 POINT FI16

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
1	0.22045E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.34164E+01	0.0	0.0
2	0.22044E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.34163E+01	0.0	0.0
3	0.19730E+01	0.10408E+03	0.10061E+04	0.19397E+01	0.0	0.60127E+00	0.0	0.0
4	0.23146E+00	0.0	0.10061E+04	0.19397E+01	0.0	0.0	0.0	0.0
5	0.19730E+01	0.10252E+03	0.10061E+04	0.19397E+01	0.0	0.61042E+00	0.0	0.0
6	0.19729E+01	0.10252E+03	0.14834E+04	0.28600E+01	0.0	0.74119E+00	0.0	0.0
7	0.19729E+01	0.10097E+03	0.14834E+04	0.28600E+01	0.0	0.75258E+00	0.0	0.0
8	0.20055E+01	0.97434E+02	0.24913E+04	0.48031E+01	0.16527E-01	0.10274E+01	0.0	0.0
9	0.20893E+01	0.97434E+02	0.24367E+04	0.46977E+01	0.15854E-01	0.10585E+01	0.0	0.0
10	0.22149E+01	0.36603E+02	0.19501E+04	0.37597E+01	0.14941E-01	0.26722E+01	0.0	0.0
11	0.22149E+01	0.36603E+02	0.19501E+04	0.37597E+01	0.14941E-01	0.26722E+01	0.0	0.0
12	0.22149E+01	0.15544E+02	0.16340E+04	0.31502E+01	0.14941E-01	0.57598E+01	0.0	0.0
13	0.22149E+01	0.15109E+02	0.16340E+04	0.31502E+01	0.14941E-01	0.59258E+01	0.0	0.0
14	0.22147E+01	0.15109E+02	0.12273E+04	0.23661E+01	0.14941E-01	0.51352E+01	0.0	0.0
15	0.22149E+01	0.14830E+02	0.12273E+04	0.23661E+01	0.14941E-01	0.52321E+01	0.12518E+00	0.14696E+02
16	0.22149E+01	0.14827E+02	0.12273E+04	0.23661E+01	0.14941E-01	0.52331E+01	0.12393E+00	0.14696E+02

275 hp
Uninstalled

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.36977E+03	0.84043E+02	0.70822E+01	0.78580E+00	0.10500E+00	0.13998E+01	0.47904E+05	0.75574E+01	0.33008E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.14994E-01	0.0	0.0	0.41475E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.15138E-01	0.0	0.0	0.27555E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.36190E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.28002E-01	0.0	0.0	0.84405E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.18465E-01	0.0	0.0	0.70022E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.24913E+04	0.10079E+04	0.35000E-01	0.11738E+03	0.99000E+00	0.0	0.10859E+07	0.23910E+06	0.14961E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.37162E+03	0.84043E+02	0.26619E+01	0.86300E+00	0.54286E+00	0.0	0.99444E+00	0.26619E+01	0.35630E+01
10	11 4 12 0	0.27637E+03	0.20000E+05	0.23548E+01	0.85600E+00	0.0	0.0	0.10045E+01	0.23548E+01	0.35630E+01

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HT EX  STATIONS     JP1 TEMP     JP2 TEMP     JM1 CORFLO  JM2 CORFLO JM1 DELP/PT JM2 DELP/PT EFFECTVNESS EFFT SCL F.  LIMIT IND
  4   5 13  6 14   0.14835E+04 0.12273E+04 0.61042E+00 0.59258E+01 0.0         0.0         0.76030E+00 0.76030E+00 0.0

NOZZL  STATIONS    GRSS THRUST NOZZLE AREA ACT JET VEL IDL JET VEL IDL VEL PR   PTIN/PAMB  DISCHG COEF  VEL COEF   NOZZLE TYPE
 13  15  0 16  0   0.13299E+02 0.50472E+02 0.19319E+03 0.19514E+03 0.10091E+01 0.10091E+01 0.10000E+01 0.99000E+00    CONV

SHAFT COMPONENTS      NET HP     ACTUAL RPM  JM1 MCH EFF JM2 MCH EFF JP1 MCH EFF JP2 MCH EFF   TORQUE     NON-TURB HP SUM ABS HP/2
 14   8  0  2  0  -0.51270E-02 0.84043E+02 0.99500E+00 0.0         0.10000E+01 0.0        -0.32040E+00-0.36977E+03 0.36976E+03
 15  10  0  0  0   0.27499E+03 0.20000E+05 0.99500E+00 0.0         0.0         0.0         0.72214E+02 0.0         0.13749E+03

CONTR  REFERENCE NOS.    VARIABLE NOS.
       DEPEND  INDEP      DEPEND    INDEP
       CPT STA  CPT     VAR STA PER  DAT    CONTR SWITCH  INDEP VAR    MIN LIMIT   MAX LIMIT   DEPEND DES ABS DEP ACT  DEPEND ERR
 16    14   0   14       1   0   0    1         ON       0.84043E+02 0.40000E+02 0.11500E+03 0.0         0.36976E+03-0.51270E-02
 17    15   0    6       1   0   0    4         OFF      0.0         0.12000E+04 0.40000E+04 0.27500E+03 0.0         0.0
 19    18   0   10       1   0   0    7         OFF      0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0
 20    15   0   10       1   0   0    5         ON       0.74999E+00 0.10000E+00 0.30000E+01 0.27500E+03 0.13749E+03-0.10254E-01
 21    15   0    1       1   0   0    1         OFF      0.0         0.50000E+00 0.10000E+02 0.30000E+03 0.0         0.0
 22    11   0   11       2   0   0    3         OFF      0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
 23    12   0   12       2   0   0    3         OFF      0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
 25    24   0   10       1   0   0    7         OFF      0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0

SCHED      REFERENCE NOS.              VARIABLE NOS.
      SCHDVAR    ARG1     ARG2     SCHDVAR      ARG1     ARG2
      CPT  STA CPT  STA CPT  STA   DAT  VAR  STA VAR  STA VAR  STA   SCHDVAR ACT SCHDVAR TBL  ARG1 ACT    ARG1 TBL    ARG2 ACT    ARG2 TBL
 18   10    0   0   11   0    0     0    8    0   0    1   0    0   0.8560^E+00 0.88000E+00 0.22149E+01 0.22149E+01 0.0         0.0
 24   10    0  15    0   0    0     0    8    0   1    0   0    0   0.85600E+00 0.85400E+00 0.27499E+03 0.27499E+03 0.0         0.0

                OVERALL ENGINE PERFORMANCE DATA

            AIR,LB/SEC   FUEL,LB/HR   GRS.JET THT  NET JET THT  PROP.THRUST *TOT.NET THT  FUEL/TOTTHT  TOTTHT/AIR  OVERBRD BLEED
             0.22044E+01  0.11738E+03  0.13299E+02  0.13299E+02  0.0          0.13299E+02  0.88262E+01  0.60329E+01  0.22044E-01

            BRAKE SH.HP  PROP. HP    *TOT.SHFT HP  FUEL/TOTSHP  TOTSHP/AIR   EQUIV.SH.HP  FUEL/ESHP    ESHP/AIR
             0.27499E+03  0.0          0.27499E+03  0.42685E+00  0.12474E+03  0.27499E+03  0.42685E+00  0.12474E+03
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98 REGENERATIVE PROPOSAL ENGINE OFF-DES 2/21/80 POINT FI16

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

	STATION	WTFLOW	TCPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
	1	0.22894E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.35479E+01	0.0	0.0
	2	0.22894E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.35479E+01	0.0	0.0
	3	0.20490E+01	0.10875E+03	0.10188E+04	0.19641E+01	0.0	0.60138E+00	0.0	0.0
	4	0.24033E+00	0.0	0.10188E+04	0.19641E+01	0.0	0.0	0.0	0.0
	5	0.20490E+01	0.10712E+03	0.10188E+04	0.19641E+01	0.0	0.61053E+00	0.0	0.0
	6	0.20490E+01	0.10712E+03	0.14878E+04	0.28683E+01	0.0	0.73781E+00	0.0	0.0
	7	0.20490E+01	0.10551E+03	0.14878E+04	0.28683E+01	0.0	0.74905E+00	0.0	0.0
4.0	8	0.20338E+01	0.10182E+03	0.25200E+04	0.48584E+01	0.16971E-01	0.10274E+01	0.0	0.0
4.1	9	0.21708E+01	0.10182E+03	0.24649E+04	0.47521E+01	0.16280E-01	0.10585E+01	0.0	0.0
	10	0.23013E+01	0.37667E+02	0.19677E+04	0.37937E+01	0.15343E-01	0.27102E+01	0.0	0.0
	11	0.23013E+01	0.37667E+02	0.19677E+04	0.37937E+01	0.15343E-01	0.27102E+01	0.0	0.0
4.5	12	0.23013E+01	0.15615E+02	0.16365E+04	0.31550E+01	0.15343E-01	0.59618E+01	0.0	0.0
	13	0.23013E+01	0.15147E+02	0.16365E+04	0.31550E+01	0.15343E-01	0.61462E+01	0.0	0.0
	14	0.23015E+01	0.15147E+02	0.12372E+04	0.23853E+01	0.15343E-01	0.53446E+01	0.0	0.0
	15	0.23070E+01	0.14844E+02	0.12372E+04	0.23853E+01	0.15343E-01	0.54667E+01	0.13092E+00	0.14696E+02
	16	0.23070E+01	0.14341E+02	0.12372E+04	0.23853E+01	0.15343E-01	0.54678E+01	0.12961E+00	0.14696E+02

300 hp
60% IRP
Uninstalled

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+0.	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.39425E+03	0.85000E+02	0.74000E+01	0.78795E+00	0.10500E+00	0.14000E+01	0.48450E+05	0.79000E+01	0.34280E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.15000E-01	0.0	0.0	0.41475E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.15000E-01	0.0	0.0	0.27555E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.36190E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.30000E-01	0.0	0.0	0.84405E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.20001E-01	0.0	0.0	0.70022E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.25200E+04	0.10322E+04	0.35000E-01	0.12519E+03	0.99000E+00	0.0	0.11082E+07	0.23557E+06	0.14228E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.39623E+03	0.85000E+02	0.27032E+01	0.86300E+00	0.54286E+00	0.0	0.10000E+01	0.27032E+01	0.35630E+01
10	11 4 12 0	0.30140E+03	0.20000E+05	0.24122E+01	0.86800E+00	0.0	0.0	0.10000E+01	0.24122E+01	0.35630E+01

HT EX	STATIONS	JP1 TEMP	JP2 TEMP	JM1 CORFLO	JM2 CORFLO	JM1 DELP/PT	JM2 DELP/PT	EFFECTVNESS	EFFT SCL F.	LIMIT IND
4	5 13 6 14	0.14878E+04	0.12372E+04	0.61053E+00	0.61462E+01	0.0	0.0	0.75930E+00	0.75930E+00	0.0

NOZZL	STATIONS	GRSS THRUST	NOZZLE AREA	ACT JET VEL	IDL JET VEL	IDL VEL PR	PTIN/PAMB	DISCHG COEF	VEL COEF	NOZZLE TYPE
13	15 0 16 0	0.14542E+02	0.50472E+02	0.20281E+03	0.20486E+03	0.10100E+01	0.10100E+01	0.10000E+01	0.99000E+00	CONV

SHAFT	COMPONENTS	NET HP	ACTUAL RPM	JM1 MCH EFF	JM2 MCH EFF	JP1 MCH EFF	JP2 MCH EFF	TORQUE	NON-TURB HP	SUM ABS HP/2
14	8 0 2 0	0.43945E-02	0.85000E+02	0.99500E+00	0.0	0.10000E+01	0.0	0.27154E+00	-0.39425E+03	0.39425E+03
15	10 0 0 0	0.29989E+03	0.20000E+05	0.99500E+00	0.0	0.0	0.0	0.78753E+02	0.0	0.14994E+03

CONTR	REFERENCE NOS. DEPEND CPT	DEPEND STA	INDEP CPT	VARIABLE NOS. DEPEND VAR	DEPEND STA	DEPEND PER	INDEP DAT	CONTR SWITCH	INDEP VAR	MIN LIMIT	MAX LIMIT	DEPEND DES	ABS DEP ACT	DEPEND ERR
16	14	0	14	1	0	0	1	ON	0.85000E+02	0.40000E+02	0.11500E+03	0.0	0.39425E+03	0.43945E-02
17	15	0	6	1	0	0	4	OFF	0.0	0.12000E+04	0.40000E+04	0.30000E+03	0.0	0.0
19	13	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0
20	15	0	10	1	0	0	5	ON	0.76064E+00	0.10000E+00	0.30000E+01	0.30000E+03	0.14994E+03	-0.11035E+00
21	15	0	1	1	0	0	1	OFF	0.0	0.50000E+00	0.10000E+02	0.30000E+03	0.0	0.0
22	11	0	11	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
23	12	0	12	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
25	24	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0

SCHED	REFERENCE NOS. SCHDVAR CPT	SCHDVAR STA	ARG1 CPT	ARG1 STA	ARG2 CPT	ARG2 STA	VARIABLE NOS. SCHDVAR DAT	SCHDVAR VAR	SCHDVAR STA	ARG1 VAR	ARG1 STA	ARG2 VAR	ARG2 STA	SCHDVAR ACT	SCHDVAR TBL	ARG1 ACT	ARG1 TBL	ARG2 ACT	ARG2 TBL
18	10	0	0	11	0	0	0	8	0	0	1	0	0	0.86800E+00	0.88000E+00	0.23013E+01	0.23013E+01	0.0	0.0
24	10	0	15	0	0	0	0	8	0	1	0	0	0	0.86800E+00	0.86196E+00	0.29989E+03	0.29989E+03	0.0	0.0

OVERALL ENGINE PERFORMANCE DATA

AIR,LB/SEC	FUEL,LB/HR	GRS.JET THT	NET JET THT	PROP.THRUST	*TOT.NET THT	FUEL/TOTTHT	TOTTHT/AIR	OVERBRD BLEED
0.22894E+01	0.12519E+03	0.14542E+02	0.14542E+02	0.0	0.14542E+02	0.86088E+01	0.63519E+01	0.22894E-01

BRAKE SH.HP	PROP. HP	*TOT.SHFT HP	FUEL/TOTSHP	TOTSHP/AIR	EQUIV.SH.HP	FUEL/ESHP	ESHP/AIR
0.29989E+03	0.0	0.29989E+03	0.41745E+00	0.13099E+03	0.29989E+03	0.41745E+00	0.13099E+03

98 REGENERATIVE PROPOSAL ENGINE OFF-DES 2/21/80 POINT FI16

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
1	0.25654E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.39757E+01	0.0	0.0
2	0.25654E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.39757E+01	0.0	0.0
3	0.22961E+01	0.12405E+03	0.10576E+04	0.20390E+01	0.0	0.60193E+00	0.0	0.0
4	0.26937E+00	0.0	0.10576E+04	0.20390E+01	0.0	0.0	0.0	0.0
5	0.22961E+01	0.12219E+03	0.10576E+04	0.20390E+01	0.0	0.61111E+00	0.0	0.0
6	0.22962E+01	0.12219E+03	0.15076E+04	0.29065E+01	0.0	0.72965E+00	0.0	0.0
7	0.22962E+01	0.12039E+03	0.15076E+04	0.29065E+01	0.0	0.74052E+00	0.0	0.0
8	0.23380E+01	0.11618E+03	0.26063E+04	0.50248E+01	0.18214E-01	0.10274E+01	0.0	0.0
9	0.24355E+01	0.11618E+03	0.25496E+04	0.49154E+01	0.17472E-01	0.10585E+01	0.0	0.0
10	0.25817E+01	0.41003E+02	0.20202E+04	0.38948E+01	0.16466E-01	0.28300E+01	0.0	0.0
11	0.25817E+01	0.41003E+02	0.20202E+04	0.38948E+01	0.16466E-01	0.28300E+01	0.0	0.0
12	0.25817E+01	0.15858E+02	0.16528E+04	0.31864E+01	0.16466E-01	0.66184E+01	0.0	0.0
13	0.25817E+01	0.15272E+02	0.16528E+04	0.31864E+01	0.16466E-01	0.68725E+01	0.0	0.0
14	0.25816E+01	0.15272E+02	0.12706E+04	0.24497E+01	0.16466E-01	0.60257E+01	0.0	0.0
15	0.25865E+01	0.14884E+02	0.12706E+04	0.24497E+01	0.16466E-01	0.61945E+01	0.14870E+00	0.14696E+02
16	0.25865E+01	0.14880E+02	0.12706E+04	0.24497E+01	0.16466E-01	0.61961E+01	0.14721E+00	0.14696E+02

375 hp
Uninstalled

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.47698E+03	0.87696E+02	0.84411E+01	0.79363E+00	0.10500E+00	0.14463E+01	0.49987E+05	0.90225E+01	0.38413E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.15027E-01	0.0	0.0	0.41475E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.14670E-01	0.0	0.0	0.27555E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.36190E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.36972E-01	0.0	0.0	0.84405E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.25424E-01	0.0	0.0	0.70022E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.26063E+04	0.10987E+04	0.35000E-01	0.15056E+03	0.99000E+00	0.0	0.11681E+07	0.22342E+06	0.12247E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.47937E+03	0.87696E+02	0.28335E+01	0.86300E+00	0.54286E+00	0.0	0.10144E+01	0.28335E+01	0.35630E+01
10	11 4 12 0	0.37695E+03	0.20000E+05	0.25855E+01	0.88000E+00	0.0	0.0	0.98693E+00	0.25855E+01	0.35630E+01

HT EX	STATIONS	JP1 TEMP	JP2 TEMP	JM1 CORFLO	JM2 CORFLO	JM1 DELP/PT	JM2 DELP/PT	EFFECTVNESS	EFFT SCL F.	LIMIT IND
4	5 13 6 14	0.15078E+04	0.12703E+04	0.61111E+00	0.68725E+01	0.0	0.0	0.75650E+00	0.75650E+00	0.0

NOZZL	STATIONS	GRSS THRUST	NOZZLE AREA	ACT JET VEL	IDL JET VEL	IDL VEL PR	PTIN/PAMB	DISCHG COEF	VEL COEF	NOZZLE TYPE
13	15 0 16 0	0.18761E+02	0.50472E+02	0.23336E+03	0.23572E+03	0.10128E+01	0.10128E+01	0.10000E+01	0.99000E+00	CONV

SHAFT	COMPONENTS	NET HP	ACTUAL RPM	JM1 MCH EFF	JM2 MCH EFF	JP1 MCH EFF	JP2 MCH EFF	TORQUE	NON-TURB HP	SUM ABS HP/2
14	8 0 2 0	-0.16113E-01	0.87696E+02	0.99500E+00	0.0	0.10000E+01	0.0	-0.96502E+00	-0.47698E+03	0.47698E+03
15	10 0 0 0	0.37507E+03	0.20000E+05	0.99500E+00	0.0	0.0	0.0	0.98494E+02	0.0	0.18753E+03

CONTR	REFERENCE NOS.			VARIABLE NOS.										
	DEPEND		INDEP	DEPEND			INDEP							
	CPT	STA	CPT	VAR	STA	PER	DAT	CONTR SWITCH	INDEP VAR	MIN LIMIT	MAX LIMIT	DEPEND DFS	ABS DEP ACT	DEPEND ERR
16	14	0	14	1	0	0	1	ON	0.87696E+02	0.40000E+02	0.11500E+03	0.0	0.47698E+03	-0.16113E-01
17	15	0	6	1	0	0	4	OFF	0.0	0.12000E+04	0.40000E+04	0.37500E+03	0.0	0.0
19	18	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0
20	15	0	10	1	0	0	5	ON	0.79428E+00	0.10000E+00	0.30000E+01	0.37500E+03	0.18753E+03	0.65674E-01
21	15	0	1	1	0	0	1	OFF	0.0	0.50000E+00	0.10000E+02	0.30000E+03	0.0	0.0
22	11	0	11	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
23	12	0	12	2	0	0	3	OFF	0.0	0.10000E-04	0.10000E-01	0.16500E-01	0.0	0.0
25	24	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0

SCHED	REFERENCE NOS.						VARIABLE NOS.												
	SCHDVAR		ARG1		ARG2		SCHDVAR			ARG1		ARG2							
	CPT	STA	CPT	STA	CPT	STA	DAT	VAR	STA	VAR	STA	VAR	STA	SCHDVAR ACT	SCHDVAR TBL	ARG1 ACT	ARG1 TBL	ARG2 ACT	ARG2 TBL
18	10	0	0	11	0	0	0	8	0	0	1	0	0	0.88000E+00	0.88000E+00	0.25817E+01	0.25817E+01	0.0	0.0
24	10	0	15	0	0	0	0	8	0	1	0	0	0	0.88000E+00	0.87999E+00	0.37507E+03	0.37507E+03	0.0	0.0

OVERALL ENGINE PERFORMANCE DATA

AIR,LB/SEC	FUEL,LB/HR	GRS.JET THT	NET JET THT	PROP.THRUST	*TOT.NET THT	FUEL/TOTTHT	TOTTHT/AIR	OVERBRD BLEED
0.25654E+01	0.15056E+03	0.18761E+02	0.18761E+02	0.0	0.18761E+02	0.80252E+01	0.73128E+01	0.25654E-01

BRAKE SH.HP	PROP. HP	*TOT.SHFT HP	FUEL/TOTSHP	TOTSHP/AIR	EQUIV.SH.HP	FUEL/ESHP	ESHP/AIR
0.37507E+03	0.0	0.37507E+03	0.40141E+00	0.14620E+03	0.37507E+03	0.40141E+00	0.14620E+03

98 REGENERATIVE PROPOSAL ENGINE OFF-DES 2/21/80 POINT FI16

COMPONENT PERFORMANCE DATA   COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT   COMPONENT ERROR SIGNAL = 0

	STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
	1	0.31909E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.49450E+01	0.0	0.0
	2	0.31909E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.49450E+01	0.0	0.0
	3	0.28561E+01	0.15884E+03	0.11516E+04	0.22203E+01	0.0	0.61018E+00	0.0	0.0
	4	0.33504E+00	0.0	0.11516E+04	0.22203E+01	0.0	0.0	0.0	0.0
	5	0.28561E+01	0.15639E+03	0.11516E+04	0.22203E+01	0.0	0.61975E+00	0.0	0.0
	6	0.28563E+01	0.15639E+03	0.15577E+04	0.30032E+01	0.0	0.72082E+00	0.0	0.0
	7	0.28563E+01	0.15415E+03	0.15577E+04	0.30032E+01	0.0	0.73129E+00	0.0	0.0
4.0	8	0.29137E+01	0.14876E+03	0.27500E+04	0.53018E+01	0.20047E-01	0.10271E+01	0.0	0.0
4.1	9	0.30349E+01	0.14876E+03	0.26917E+04	0.51894E+01	0.19231E-01	0.10585E+01	0.0	0.0
	10	0.32168E+01	0.45753E+02	0.20848E+04	0.40193E+01	0.18124E-01	0.32102E+01	0.0	0.0
	11	0.32168E+01	0.45753E+02	0.20848E+04	0.40193E+01	0.18124E-01	0.32102E+01	0.0	0.0
4.5	12	0.32165E+01	0.16531E+02	0.16946E+04	0.32670E+01	0.18124E-01	0.80104E+01	0.0	0.0
	13	0.32165E+01	0.15635E+02	0.16946E+04	0.32670E+01	0.18124E-01	0.84685E+01	0.0	0.0
	14	0.32165E+01	0.15635E+02	0.13506E+04	0.26038E+01	0.18124E-01	0.75603E+01	0.0	0.0
	15	0.32089E+01	0.15010E+02	0.13506E+04	0.26038E+01	0.18124E-01	0.78566E+01	0.19007E+00	0.14696E+02
	16	0.32089E+01	0.15004E+02	0.13506E+04	0.26038E+01	0.18124E-01	0.78599E+01	0.18817E+00	0.14696E+02

500 hp
IRP
Uninstalled

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 2 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.70014E+03	0.95040E+02	0.10809E+02	0.77994E+00	0.10500E+00	0.15956E+01	0.54173E+05	0.11575E+02	0.47778E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.15442E-01	0.0	0.0	0.41475E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.14317E-01	0.0	0.0	0.27555E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.36190E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 0	0.54160E-01	0.0	0.0	0.84405E-03	0.0	0.0	0.0	0.0	0.0
12	14 0 15 0	0.40023E-01	0.0	0.0	0.70022E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.27500E+04	0.11923E+04	0.35000E-01	0.20614E+03	0.99000E+00	0.0	0.12490E+07	0.19604E+06	0.92922E-01

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.70346E+03	0.95040E+02	0.32513E+01	0.86300E+00	0.54286E+00	0.0	0.10700E+01	0.32513E+01	0.35630E+01
10	11 4 12 0	0.50268E+03	0.20000E+05	0.27678E+01	0.85800E+00	0.0	0.0	0.97152E+00	0.27678E+01	0.35630E+01

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HT EX  STATIONS     JP1 TEMP    JP2 TEMP    JM1 CORFLO  JM2 CORFLO JM1 DELP/PT JM2 DELP/PT EFFECTVNESS EFFT SCL F.  LIMIT IND
  4   5 13  6 14  0.15577E+04 0.13506E+04 0.61975E+00 0.84685E+01 0.0         0.0         0.74800E+00 0.74800E+00 0.0

NOZZL  STATIONS    GRSS THRUST NOZZLE AREA ACT JET VEL IDL JET VEL IDL VEL PR   PTIN/PAMB  DISCHG COEF  VEL COEF   NOZZLE TYPE
 13  15  0 16  0  0.30630E+02 0.50472E+02 0.30712E+03 0.31022E+03 0.10213E+01 0.10213E+01 0.10000E+01 0.99000E+00    CONV

SHAFT COMPONENTS     NET HP     ACTUAL RPM JM1 MCH EFF JM2 MCH EFF JP1 MCH EFF JP2 MCH EFF   TORQUE    NON-TURB HP SUM ABS HP/2
 14    8  0  2  0  -0.20435E+00 0.95040E+02 0.99500E+00 0.0         0.10000E+01 0.0        -0.11293E+02-0.70014E+03 0.70004E+03
 15   10  0  0  0   0.50016E+03 0.20000E+05 0.99500E+00 0.0         0.0         0.0         0.13135E+03 0.0         0.25008E+03

CONTR  REFERENCE NOS.    VARIABLE NOS.
       DEPEND  INDEP     DEPEND     INDEP
       CPT STA  CPT     VAR STA PER  DAT   CONTR SWITCH  INDEP VAR    MIN LIMIT   MAX LIMIT   DEPEND DES ABS DEP ACT  DEPEND ERR
 16     14   0   14      1   0 . 0    1         ON      0.95040E+02 0.40000E+02 0.11500E+03 0.0         0.70004E+03-0.20435E+00
 17     15   0    6      1   0   0    4         OFF     0.0         0.12000E+04 0.40000E+04 0.50000E+03 0.0         0.0
 19     18   0   10      1   0   0    7         OFF     0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0
 20     15   0   10      1   0   0    5         ON      0.90098E+00 0.10000E+00 0.30000E+01 0.50000E+03 0.25008E+03 0.16357E+00
 21     15   0    1      1   0   0    1         OFF     0.0         0.50000E+00 0.10000E+02 0.30000E+03 0.0         0.0
 22     11   0   11      2   0   0    3         OFF     0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
 23     12   0   12      2   0   0    3         OFF     0.0         0.10000E-04 0.10000E-01 0.16500E-01 0.0         0.0
 25     24   0   10      1   0   0    7         OFF     0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0

SCHED      REFERENCE NOS.                VARIABLE NOS.
      SCHDVAR   ARG1     ARG2      SCHDVAR     ARG1    ARG2
      CPT STA CPT  STA CPT STA   DAT VAR STA VAR STA VAR STA  SCHDVAR ACT SCHDVAR TBL  ARG1 ACT    ARG1 TBL    ARG2 ACT    ARG2 TBL
 18    10   0   0  11   0   0     0   8   0   0   1   0   0  0.85800E+00 0.88000E+00 0.32168E+01 0.32168E+01 0.0          0.0
 24    10   0  15   0   0   0     0   8   0   1   0   0   0  0.85800E+00 0.85899E+00 0.50016E+03 0.50016E+03 0.0          0.0

                  OVERALL ENGINE PERFORMANCE DATA

              AIR,LB/SEC   FUEL,LB/HR   GRS.JET THT  NET JET THT  PROP.THRUST *TOT.NET THT  FUEL/TOTTHT  TOTTHT/AIR  OVERBRD BLEED
               0.31909E+01  0.20614E+03  0.30630E+02  0.30630E+02  0.0          0.30630E+02  0.67299E+01  0.95993E+01  0.31909E-01

              BRAKE SH.HP  PROP. HP    *TOT.SHFT HP  FUEL/TOTSHP  TOTSHP/AIR   EQUIV.SH.HP  FUEL/ESHP    ESHP/AIR
               0.50016E+03  0.0          0.50016E+03  0.41214E+00  0.15675E+03  0.50016E+03  0.41214E+00  0.15675E+03
```

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

	STATION	WTFLOW	TOTPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
	1	0.18213E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.28225E+01	0.0	0.0
	2	0.18213E+01	0.14654E+02	0.51869E+03	0.10000E+01	0.0	0.28306E+01	0.0	0.0
	3	0.15935E+01	0.65472E+02	0.87710E+03	0.16910E+01	0.0	0.72082E+00	0.0	0.0
	4	0.22766E+00	0.0	0.87710E+03	0.16910E+01	0.0	0.0	0.0	0.0
	5	0.15935E+01	0.64369E+02	0.87710E+03	0.16910E+01	0.0	0.73317E+00	0.0	0.0
	6	0.15935E+01	0.64369E+02	0.12971E+04	0.25006E+01	0.0	0.89158E+00	0.0	0.0
	7	0.15935E+01	0.63260E+02	0.12971E+04	0.25006E+01	0.0	0.90709E+00	0.0	0.0
4.0	8	0.16094E+01	0.61054E+02	0.19400E+04	0.37401E+01	0.99430E-02	0.11610E+01	0.0	0.0
4.1	9	0.15786E+01	0.61054E+02	0.18991E+04	0.36614E+01	0.95292E-02	0.11981E+01	0.0	0.0
	10	0.17824E+01	0.22525E+02	0.15018E+04	0.28953E+01	0.89692E-02	0.30665E+01	0.0	0.0
	11	0.17823E+01	0.22525E+02	0.15018E+04	0.28953E+01	0.89692E-02	0.30663E+01	0.0	0.0
4.5	12	0.17322E+01	0.15074E+02	0.14263E+04	0.27498E+01	0.89692E-02	0.44652E+01	0.0	0.0
	13	0.17323E+01	0.14854E+02	0.14263E+04	0.27498E+01	0.89692E-02	0.44041E+01	0.0	0.0
	14	0.17322E+01	0.14854E+02	0.10520E+04	0.20282E+01	0.89692E-02	0.37822E+01	0.0	0.0
	15	0.17271E+01	0.14794E+02	0.10520E+04	0.20282E+01	0.89692E-02	0.37867E+01	0.10751E+00	0.14696E+02
	16	0.17271E+01	0.14792E+02	0.10520E+04	0.20282E+01	0.89692E-02	0.37872E+01	0.10643E+00	0.14696E+02
	17	0.18213E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.28225E+01	0.0	0.0
	18	0.49965E-01	0.14854E+02	0.14263E+04	0.27498E+01	0.89692E-02	0.12711E+00	0.0	0.0

50 hp
Installed

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 17 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.22333E+03	0.75024E+02	0.44679E+01	0.76599E+00	0.12500E+00	0.15223E+01	0.42764E+05	0.47380E+01	0.23637E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WDAV	WDOUT/WDUCT
3	3 0 5 0	0.16941E-01	0.0	0.0	0.32412E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.17104E-01	0.0	0.0	0.21517E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30400E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 18	0.14564E-01	0.0	0.0	0.73046E-03	0.0	0.0	0.0	0.0	0.28052E-01
12	14 0 15 0	0.40976E-02	0.0	0.0	0.28645E-03	0.0	0.0	0.0	0.0	0.0
26	17 0 2 0	0.28706E-02	0.0	0.0	0.36034E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.19400E+04	0.64300E+03	0.35000E-01	0.57040E+02	0.99000E+00	0.0	0.84209E+06	0.26949E+06	0.30776E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.23518E+03	0.75024E+02	0.27105E+01	0.86300E+00	0.45600E+00	0.0	0.10053E+01	0.27105E+01	0.35630E+01
10	11 4 12 0	0.50753E+02	0.20000E+05	0.14943E+01	0.51300E+00	0.0	0.0	0.11353E+01	0.14943E+01	0.33433E+01

HT EX	STATIONS	JP1 TEMP	JP2 TEMP	JM1 CORFLO	JM2 CORFLO	JM1 DELP/PT	JM2 DELP/PT	EFFECTVNESS	EFFT SCL F.	LIMIT IND
4	5 13 6 14	0.12970E+04	0.10519E+04	0.73317E+00	0.44041E+01	0.0	0.0	0.76460E+00	0.76460E+00	0.0

NOZZL	STATIONS	GRSS THRUST	NOZZLE AREA	ACT JET VEL	IDL JET VEL	IDL VEL FR	PTIN/PAMB	DISCHG COEF	VEL COEF	NOZZLE TYPE
13	15 0 16 0	0.82627E+01	0.42360E+02	0.15392E+03	0.15547E+03	0.10066E+01	0.10066E+01	0.10000E+01	0.99000E+00	CONV

SHAFT	COMPONENTS	NET HP	ACTUAL RPM	JM1 MCH EFF	JM2 MCH EFF	JP1 MCH EFF	JP2 MCH EFF	TORQUE	NON-TURB HP	SUM ABS HP/2
14	8 0 2 18	0.22940E-01	0.75024E+02	0.99500E+00	0.0	0.10000E+01	0.10000E+01	0.16059E+01	-0.23399E+03	0.23399E+03
15	10 0 0 0	0.49992E+02	0.20000E+05	0.98500E+00	0.0	0.0	0.0	0.13128E+02	0.0	0.24996E+02

LOAD	HORSEPOWER	HP FACTOR	ACTUAL RPM	RPM FACTOR
18	-0.10600E+02	0.10600E+02	0.75024E+02	0.10000E+01

CONTR	REFERENCE NOS. DEPEND CPT	DEPEND STA	INDEP CPT	VARIABLE NOS. DEPEND VAR	DEPEND STA	DEPEND PER	INDEP CAT	CONTR SWITCH	INDEP VAR	MIN LIMIT	MAX LIMIT	DEPEND DES	ABS DEP ACT	DEPEND ERR
16	14	0	14	1	0	0	1	ON	0.75024E+02	0.40000E+02	0.11500E+03	0.0	0.23399E+03	0.22940E-01
17	15	0	6	1	0	0	4	ON	0.19400E+04	0.12000E+04	0.40000E+04	0.50000E+02	0.24996E+02	-0.83466E-02
19	0	18	11	0	1	0	9	ON	0.28052E-01	0.10000E-03	0.99000E+00	0.50000E-01	0.49996E-01	-0.43176E-05
20	15	0	10	1	0	0	5	OFF	0.0	0.10000E+00	0.30000E+01	0.50000E+02	0.0	0.0
21	15	0	1	1	0	0	1	OFF	0.0	0.50000E+00	0.10000E+02	0.30000E+03	0.0	0.0
22	11	0	11	2	0	0	3	OFF	0.0	0.0	0.10000E+00	0.33000E-01	0.0	0.0
23	12	0	12	2	0	0	3	OFF	0.0	0.0	0.10000E+00	0.10000E-01	0.0	0.0
25	24	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0
27	26	0	6	2	0	0	3	OFF	0.0	0.0	0.10000E+00	0.60000E-02	0.0	0.0
28	9	0	9	2	0	0	3	OFF	0.0	0.0	0.10000E+00	0.10000E-01	0.0	0.0

SCHED	REFERENCE NOS. SCHDVAR CPT	SCHDVAR STA	ARG1 CPT	ARG1 STA	ARG2 CPT	ARG2 STA	VARIABLE NOS. SCHDVAR DAT	SCHDVAR VAR	SCHDVAR STA	ARG1 VAR	ARG1 STA	ARG2 VAR	ARG2 STA	SCHDVAR ACT	SCHDVAR TBL	ARG1 ACT	ARG1 TBL	ARG2 ACT	ARG2 TBL
24	10	0	15	0	0	0	0	8	0	1	0	0	0	0.51300E+00	0.86000E+00	0.49992E+02	0.49992E+02	0.0	0.0

OVERALL ENGINE PERFORMANCE DATA

AIR,LB/SEC	FUEL,LB/HR	GRS.JET THT	NET JET THT	PROP.THRUST	*TOT.NET THT	FUEL/TOTTHT	TOTTHT/AIR	OVERBRD BLEED
0.18213E+01	0.57040E+02	0.82627E+01	0.82627E+01	0.0	0.82627E+01	0.69032E+01	0.45368E+01	0.10463E+00

BRAKE SH.HP	PROP. HP	*TOT.SHFT HP	FUEL/TOTSHP	TOTSHP/AIR	EQUIV.SH.HP	FUEL/ESHP	ESHP/AIR
0.49992E+02	0.0	0.49992E+02	0.11410E+01	0.27449E+02	0.49992E+02	0.11410E+01	0.27449E+02

98 REGEN. PROP. ENG. INSTALLED 12/9/80 POINT FIIS

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
1	0.23461E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.36358E+01	0.0	0.0
2	0.23461E+01	0.14626E+02	0.51869E+03	0.10000E+01	0.0	0.36532E+01	0.0	0.0
3	0.20529E+01	0.92513E+02	0.97122E+03	0.18724E+01	0.0	0.69155E+00	0.0	0.0
4	0.29326E+00	0.0	0.97122E+03	0.18724E+01	0.0	0.0	0.0	0.0
5	0.20529E+01	0.91079E+02	0.97122E+03	0.18724E+01	0.0	0.70244E+00	0.0	0.0
6	0.20529E+01	0.91079E+02	0.14207E+04	0.27391E+01	0.0	0.84959E+00	0.0	0.0
7	0.20529E+01	0.89665E+02	0.14207E+04	0.27391E+01	0.0	0.86299E+00	0.0	0.0
8	0.20828E+01	0.86526E+02	0.23296E+04	0.44914E+01	0.14655E-01	0.11618E+01	0.0	0.0
9	0.21719E+01	0.86526E+02	0.22783E+04	0.43924E+01	0.14045E-01	0.11981E+01	0.0	0.0
10	0.23057E+01	0.29891E+02	0.17888E+04	0.34487E+01	0.13219E-01	0.32624E+01	0.0	0.0
11	0.23056E+01	0.29891E+02	0.17888E+04	0.34487E+01	0.13219E-01	0.32623E+01	0.0	0.0
12	0.23056E+01	0.15309E+02	0.15624E+04	0.30122E+01	0.13219E-01	0.59218E+01	0.0	0.0
13	0.22556E+01	0.14995E+02	0.15624E+04	0.30122E+01	0.13219E-01	0.59457E+01	0.0	0.0
14	0.22555E+01	0.14995E+02	0.11693E+04	0.22542E+01	0.13219E-01	0.51435E+01	0.0	0.0
15	0.22512E+01	0.14881E+02	0.11693E+04	0.22542E+01	0.13219E-01	0.51727E+01	0.14770E+00	0.14696E+02
16	0.22512E+01	0.14878E+02	0.11693E+04	0.22542E+01	0.13219E-01	0.51740E+01	0.14622E+00	0.14696E+02
17	0.23461E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.36358E+01	0.0	0.0
18	0.49995E-01	0.14995E+02	0.15624E+04	0.30122E+01	0.13219E-01	0.13179E+00	0.0	0.0

200 hp
Installed

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 17 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.36476E+03	0.82403E+02	0.63253E+01	0.78494E+00	0.12500E+00	0.14950E+01	0.46970E+05	0.67413E+01	0.30506E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.15501E-01	0.0	0.0	0.32412E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.15531E-01	0.0	0.0	0.21517E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30400E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 18	0.25616E-01	0.0	0.0	0.73046E-03	0.0	0.0	0.0	0.0	0.21694E-01
12	14 0 15 0	0.75780E-02	0.0	0.0	0.28645E-03	0.0	0.0	0.0	0.0	0.0
26	17 0 2 0	0.47633E-02	0.0	0.0	0.36034E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.23296E+04	0.90889E+03	0.35000E-01	0.10830E+03	0.99000E+00	0.0	0.11282E+07	0.27317E+06	0.19740E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.38792E+03	0.82403E+02	0.28947E+01	0.86300E+00	0.45600E+00	0.0	0.10081E+01	0.28947E+01	0.35630E+01
10	11 4 12 0	0.20303E+03	0.20000E+05	0.19423E+01	0.83100E+00	0.0	0.0	0.10402E+01	0.19423E+01	0.35597E+01

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HT EX  STATIONS    JP1 TEMP    JP2 TEMP    JM1 CORFLO  JM2 CORFLO JM1 DELP/PT JM2 DELP/PT EFFECTVNESS EFFT SCL F.  LIMIT IND
  4    5 13  6 14  0.14207E+04 0.11693E+04 0.70244E+00 0.59457E+01 0.0         0.0         0.76040E+00 0.76040E+00 0.0

NOZZL  STATIONS    GRSS THRUST NOZZLE AREA ACT JET VEL IDL JET VEL IDL VEL FR   PTIN/PAMB  DISCHG COEF  VEL COEF   NOZZLE TYPE
 13  15  0 16  0   0.15580E+02 0.42360E+02 0.22267E+03 0.22492E+03 0.10126E+01 0.10126E+01 0.10000E+01 0.99000E+00    CONV

SHAFT COMPONENTS      NET HP    ACTUAL RPM JM1 MCH EFF JM2 MCH EFF JP1 MCH EFF JP2 MCH EFF    TORQUE    NON-TURB HP SUM ABS HP/2
 14    8  0  2 18  0.13382E-01 0.82403E+02 0.99500E+00 0.0         0.10000E+01 0.10000E+01 0.85292E+00-0.33596E+03 0.33597E+03
 15   10  0  0  0  0.19993E+03 0.20000E+05 0.98500E+00 0.0         0.0         0.0         0.52516E+02 0.0         0.99991E+02

LOAD                HORSEPOWER  HP FACTOR   ACTUAL RPM  RPM FACTOR
 18               -0.21200E+02 0.21200E+02 0.82403E+02 0.10000E+01

CONTR  REFERENCE NOS.    VARIABLE NOS.
       DEPEND  INDEP     DEPEND     INDEP
       CPT STA  CPT    VAR STA PER  DAT    CONTR SWITCH  INDEP VAR   MIN LIMIT   MAX LIMIT   DEPEND DES ABS DEP ACT  DEPEND ERR
 16     14   0   14      1   0   0    1         ON       0.82403E+02 0.40000E+02 0.11500E+03 0.0         0.38597E+03 0.13382E-01
 17     15   0    6      1   0   0    4         ON       0.23296E+04 0.12000E+04 0.40000E+04 0.20000E+03 0.99991E+02-0.17960E-01
 19      0  18   11      0   1   0    9         ON       0.21684E-01 0.10000E-03 0.99000E+00 0.50000E-01 0.49995E-01-0.52042E-05
 20     15   0   10      1   0   0    5         OFF      0.0         0.10050E+00 0.30000E+01 0.20000E+03 0.0         0.0
 21     15   0    1      1   0   0    1         OFF      0.0         0.50000E+00 0.10000E+02 0.30000E+03 0.0         0.0
 22     11   0   11      2   0   0    3         OFF      0.0         0.0         0.10000E+00 0.33000E-01 0.0         0.0
 23     12   0   12      2   0   0    3         OFF      0.0         0.0         0.10000E+00 0.10000E-01 0.0         0.0
 25     24   0   10      1   0   0    7         OFF      0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0
 27     26   0   26      2   0   0    3         OFF      0.0         0.0         0.10000E+00 0.60000E-02 0.0         0.0
 28      9   0    9      2   0   0    3         OFF      0.0         0.0         0.10000E+00 0.10000E-01 0.0         0.0

SCHED     REFERENCE NOS.              VARIABLE NOS.
      SCHDVAR   ARG1    ARG2      SCHDVAR     ARG1    ARG2
      CPT STA CPT STA CPT STA   DAT VAR STA VAR STA VAR STA  SCHDVAR ACT SCHDVAR TBL  ARG1 ACT    ARG1 TBL    ARG2 ACT    ARG2 TBL
 24    10   0  15   0   0   0     0   8   0   1   0   0   0  0.83100E+00 0.86000E+00 0.19998E+03 0.19998E+03 0.0         0.0

              OVERALL ENGINE PERFORMANCE DATA

           AIR,LB/SEC  FUEL,LB/HR  GRS.JET THT  NET JET THT  PROP.THRUST *TOT.NET THT  FUEL/TOTTHT  TOTTHT/AIR  OVERBRD BLEED
           0.23461E+01 0.10830E+03 0.15580E+02 0.15580E+02 0.0          0.15580E+02 0.69515E+01 0.66408E+01 0.12038E+00

           BRAKE SH.HP  PROP. HP   *TOT.SHFT HP  FUEL/TOTSHP  TOTSHP/AIR  EQUIV.SH.HP  FUEL/ESHP   ESHP/AIR
           0.19998E+03 0.0          0.19998E+03 0.54157E+00 0.85240E+02 0.19998E+03 0.54157E+00 0.85240E+02
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98 REGEN. PROP. ENG. INSTALLED 12/9/80 POINT FIIS

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
1	0.25449E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.39438E+01	0.0	0.0
2	0.25449E+01	0.14614E+02	0.51869E+03	0.10000E+01	0.0	0.39661E+01	0.0	0.0
3	0.22268E+01	0.10384E+03	0.10071E+04	0.19415E+01	0.0	0.68049E+00	0.0	0.0
4	0.31811E+00	0.0	0.10071E+04	0.19415E+01	0.0	0.0	0.0	0.0
5	0.22268E+01	0.10228E+03	0.10071E+04	0.19415E+01	0.0	0.69086E+00	0.0	0.0
6	0.22268E+01	0.10228E+03	0.14836E+04	0.28602E+01	0.0	0.83852E+00	0.0	0.0
7	0.22268E+01	0.10074E+03	0.14836E+04	0.28602E+01	0.0	0.85140E+00	0.0	0.0
8	0.22634E+01	0.97212E+02	0.24913E+04	0.48031E+01	0.16525E-01	0.11621E+01	0.0	0.0
9	0.23601E+01	0.97212E+02	0.24355E+04	0.46955E+01	0.15837E-01	0.11981E+01	0.0	0.0
10	0.25051E+01	0.33587E+02	0.19166E+04	0.36951E+01	0.14906E-01	0.32653E+01	0.0	0.0
11	0.25051E+01	0.33587E+02	0.19166E+04	0.36951E+01	0.14906E-01	0.32653E+01	0.0	0.0
12	0.25051E+01	0.15550E+02	0.16338E+04	0.31499E+01	0.14906E-01	0.65119E+01	0.0	0.0
13	0.24551E+01	0.15068E+02	0.16338E+04	0.31499E+01	0.14906E-01	0.65859E+01	0.0	0.0
14	0.24551E+01	0.15068E+02	0.12202E+04	0.23525E+01	0.14906E-01	0.56916E+01	0.0	0.0
15	0.24627E+01	0.14928E+02	0.12202E+04	0.23525E+01	0.14906E-01	0.57626E+01	0.16506E+00	0.14696E+02
16	0.24627E+01	0.14924E+02	0.12202E+04	0.23525E+01	0.14906E-01	0.57644E+01	0.16341E+00	0.14696E+02
17	0.25449E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.39438E+01	0.0	0.0
18	0.50000E-01	0.15068E+02	0.16338E+04	0.31499E+01	0.14906E-01	0.13412E+00	0.0	0.0

275 hp
Installed

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 17 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.42774E+03	0.84120E+02	0.71059E+01	0.78596E+00	0.12500E+00	0.14018E+01	0.47949E+05	0.75329E+01	0.33118E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.15009E-01	0.0	0.0	0.32412E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.15129E-01	0.0	0.0	0.21517E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30400E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 18	0.30975E-01	0.0	0.0	0.73046E-03	0.0	0.0	0.0	0.0	0.19959E-01
12	14 0 15 0	0.92792E-02	0.0	0.0	0.28645E-03	0.0	0.0	0.0	0.0	0.0
26	17 0 2 0	0.56046E-02	0.0	0.0	0.36034E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.24913E+04	0.10077E+04	0.35000E-01	0.13247E+03	0.99000E+00	0.0	0.12283E+07	0.27094E+06	0.16964E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.45116E+03	0.84120E+02	0.28943E+01	0.86300E+00	0.45600E+00	0.0	0.99535E+00	0.28943E+01	0.35630E+01
10	11 4 12 0	0.27915E+03	0.20000E+05	0.21600E+01	0.85600E+00	0.0	0.0	0.10049E+01	0.21600E+01	0.35630E+01

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HT EX  STATIONS     JP1 TEMP     JP2 TEMP     JM1 CORFLO   JM2 CORFLO  JM1 DELP/PT JM2 DELP/PT EFFECTVNESS EFFT SCL F.  LIMIT IND
  4    5 13  6 14  0.14836E+04 0.12202E+04 0.69086E+00 0.65859E+01 0.0          0.0          0.76030E+00 0.76030E+00 0.0

NOZZL  STATIONS    GRSS THRUST NOZZLE AREA ACT JET VEL IDL JET VEL IDL VEL PR   PTIN/PAMB  DISCHG COEF  VEL COEF   NOZZLE TYPE
 13  15  0 16  0   0.19444E+02 0.42360E+02 0.25402E+03 0.25659E+03 0.10158E+01 0.10158E+01 0.10000E+01 0.99000E+00    CONV

SHAFT COMPONENTS     NET HP     ACTUAL RPM JM1 MCH EFF JM2 MCH EFF JP1 MCH EFF JP2 MCH EFF    TORQUE     NON-TURB HP SUM ABS HP/2
 14   8  0  2 18  -0.33981E-01 0.84120E+02 0.99500E+00 0.0         0.10000E+01 0.10000E+01-0.21216E+01-0.44894E+03 0.44892E+03
 15  10  0  0  0   0.27497E+03 0.20000E+05 0.98500E+00 0.0         0.0         0.0         0.72208E+02 0.0         0.13748E+03

LOAD                HORSEPOWER  HP FACTOR   ACTUAL RPM  RPM FACTOR
 18               -0.21200E+02 0.21200E+02 0.84120E+02 0.10000E+01

CONTR  REFERENCE NOS.    VARIABLE NOS.
       DEPEND  INDEP     DEPEND     INDEP
       CPT STA  CPT     VAR STA PER  DAT   CONTR SWITCH  INDEP VAR    MIN LIMIT    MAX LIMIT   DEPEND DES ABS DEP ACT  DEPEND ERR
 16    14   0   14       1   0   0    1        ON       0.84120E+02 0.40000E+02 0.11500E+03 0.0         0.44092E+03-0.33981E-01
 17    15   0    6       1   0   0    4        OFF      0.0         0.12000E+04 0.40000E+04 0.27500E+03 0.0          0.0
 19     0  18   11       0   1   0    9        ON       0.19959E-01 0.10000E-03 0.99000E+00 0.50000E-01 0.50000E-01-0.10058E-06
 20    15   0   10       1   0   0    5        ON       0.91645E+00 0.10000E+00 0.30000E+01 0.27500E+03 0.13748E+03-0.33447E-01
 21    15   0    1       1   0   0    1        OFF      0.0         0.50000E+00 0.10000E+02 0.30000E+03 0.0          0.0
 22    11   0   11       2   0   0    3        OFF      0.0         0.0         0.10000E+00 0.33000E-01 0.0          0.0
 23    12   0   12       2   0   0    3        OFF      0.0         0.0         0.10000E+00 0.10000E-01 0.0          0.0
 25    24   0   10       1   0   0    7        OFF      0.0         0.10000E+00 0.20000E+01 0.0         0.0          0.0
 27    26   0   26       2   0   0    3        OFF      0.0         0.0         0.10000E+00 0.60000E-02 0.0          0.0
 28     9   0    9       2   0   0    3        OFF      0.0         0.0         0.10000E+00 0.10000E-01 0.0          0.0

SCHED     REFERENCE NOS.                VARIABLE NOS.
      SCHDVAR   ARG1    ARG2      SCHDVAR     ARG1     ARG2
      CPT STA CPT STA CPT STA   DAT VAR STA VAR STA VAR STA  SCHDVAR ACT SCHDVAR TBL  ARG1 ACT    ARG1 TBL    ARG2 ACT    ARG2 TBL
 24   10   0  15   0   0   0     0   8   0   1   0   0   0   0.85600E+00 0.86000E+00 0.27497E+03 0.27497E+03 0.0         0.0

               OVERALL ENGINE PERFORMANCE DATA

           AIR,LB/SEC   FUEL,LB/HR   GRS.JET THT  NET JET THT  PROP.THRUST *TOT.NET THT  FUEL/TOTTHT  TOTTHT/AIR  OVERSPD BLEED
            0.25449E+01  0.13247E+03  0.19444E+02  0.19444E+02  0.0          0.19444E+02  0.68128E+01  0.76405E+01  0.12635E+00

           BRAKE SH.HP  PROP. HP    *TOT.SHFT HP  FUEL/TOTSHP  TOTSHP/AIR   EQUIV.SH.HP  FUEL/ESHP    ESHP/AIR
            0.27497E+03  0.0          0.27497E+03  0.48176E+00  0.10805E+03  0.27497E+03  0.48176E+00  0.10805E+03
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98 REGENERATIVE PROPOSAL ENGINE INST DES PT 12/9/80 PT FIIS

COMPONENT PERFORMANCE DATA   COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT   COMPONENT ERROR SIGNAL = 0

STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
1	0.26331E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.40806E+01	0.0	0.0
2	0.26331E+01	0.14608E+02	0.51869E+03	0.10000E+01	0.0	0.41052E+01	0.0	0.0
3	0.23039E+01	0.10810E+03	0.10188E+04	0.19641E+01	0.0	0.68028E+00	0.0	0.0
4	0.32913E+00	0.0	0.10188E+04	0.19641E+01	0.0	0.0	0.0	0.0
5	0.23039E+01	0.10648E+03	0.10188E+04	0.19641E+01	0.0	0.69064E+00	0.0	0.0
6	0.23040E+01	0.10648E+03	0.14889E+04	0.28705E+01	0.0	0.83497E+00	0.0	0.0
7	0.23040E+01	0.10488E+03	0.14889E+04	0.28705E+01	0.0	0.84768E+00	0.0	0.0
8	0.23430E+01	0.10121E+03	0.25200E+04	0.48584E+01	0.16953E-01	0.11621E+01	0.0	0.0
9	0.24431E+01	0.10121E+03	0.24636E+04	0.47498E+01	0.16248E-01	0.11981E+01	0.0	0.0
10	0.25932E+01	0.34569E+02	0.19355E+04	0.37316E+01	0.15293E-01	0.33002E+01	0.0	0.0
11	0.25932E+01	0.34569E+02	0.19355E+04	0.37316E+01	0.15293E-01	0.33002E+01	0.0	0.0
12	0.25932E+01	0.15615E+02	0.16380E+04	0.31579E+01	0.15293E-01	0.67211E+01	0.0	0.0
13	0.25432E+01	0.15100E+02	0.16380E+04	0.31579E+01	0.15293E-01	0.68165E+01	0.0	0.0
14	0.25433E+01	0.15100E+02	0.12306E+04	0.23725E+01	0.15293E-01	0.59085E+01	0.0	0.0
15	0.25462E+01	0.14949E+02	0.12306E+04	0.23725E+01	0.15293E-01	0.59752E+01	0.17136E+00	0.14696E+02
16	0.25462E+01	0.14943E+02	0.12306E+04	0.23725E+01	0.15293E-01	0.59773E+01	0.16964E+00	0.14696E+02
17	0.26331E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.40806E+01	0.0	0.0
18	0.50000E-01	0.15100E+02	0.16380E+04	0.31579E+01	0.15293E-01	0.13402E+00	0.0	0.0

300 hp
60% IRP
Installed

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 17 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.45343E+03	0.85000E+02	0.74000E+01	0.78795E+00	0.12500E+00	0.14000E+01	0.48450E+05	0.79000E+01	0.34280E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.15000E-01	0.0	0.0	0.32412E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.15001E-01	0.0	0.0	0.21517E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.39400E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 18	0.32997E-01	0.0	0.0	0.73046E-03	0.0	0.0	0.0	0.0	0.19782E-01
12	14 0 15 0	0.10000E-01	0.0	0.0	0.28645E-03	0.0	0.0	0.0	0.0	0.0
26	17 0 2 0	0.60000E-02	0.0	0.0	0.36034E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.25200E+04	0.10311E+04	0.35000E-01	0.14062E+03	0.99000E+00	0.0	0.12524E+07	0.26749E+06	0.16193E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.47702E+03	0.85000E+02	0.29277E+01	0.86300E+00	0.45600E+00	0.0	0.10000E+01	0.29277E+01	0.35630E+01
10	11 4 12 0	0.30457E+03	0.20000E+05	0.22139E+01	0.86000E+00	0.0	0.0	0.10000E+01	0.22139E+01	0.35630E+01

12
F

HT EX	STATIONS	JP1 TEMP	JP2 TEMP	JM1 CORFLO	JM2 CORFLO	JM1 DELP/PT	JM2 DELP/PT	EFFECTVNESS	EFFT SCL F.	LIMIT IND
4	5 13 6 14	0.14889E+04	0.12306E+04	0.69064E+00	0.68165E+01	0.0	0.0	0.75930E+00	0.75930E+00	0.0

NOZZL	STATIONS	GRSS THRUST	NOZZLE AREA	ACT JET VEL	IDL JET VEL	IDL VEL PR	PTIN/PAMB	DISCHG COEF	VEL COEF	NOZZLE TYPE
13	15 0 16 0	0.20955E+02	0.42360E+02	0.26478E+03	0.26746E+03	0.10172E+01	0.10172E+01	0.10000E+01	0.99000E+00	CONV

SHAFT	COMPONENTS	NET HP	ACTUAL RPM	JM1 MCH EFF	JM2 MCH EFF	JP1 MCH EFF	JP2 MCH EFF	TORQUE	NON-TURB HP	SUM ABS HP/2
14	8 0 2 18	0.55695E-02	0.85000E+02	0.99500E+00	0.0	0.10000E+01	0.10000E+01	0.34413E+00	-0.47463E+03	0.47463E+03
15	10 0 0 0	0.30000E+03	0.20000E+05	0.98500E+00	0.0	0.0	0.0	0.70783E+02	0.0	0.15000E+03

LOAD	HORSEPOWER	HP FACTOR	ACTUAL RPM	RPM FACTOR
18	-0.21200E+02	0.21200E+02	0.85000E+02	0.10000E+01

CONTR	REFERENCE NOS. DEPEND CPT	DEPEND STA	INDEP CPT	VARIABLE NOS. DEPEND VAR	DEPEND STA	DEPEND PER	INDEP DAT	CONTR SWITCH	INDEP VAR	MIN LIMIT	MAX LIMIT	DEPEND DES	ABS DEP ACT	DEPEND ERR
16	14	0	14	1	0	0	1	ON	0.85000E+02	0.40000E+02	0.11500E+03	0.0	0.47463E+03	0.55695E-02
17	15	0	6	1	0	0	4	OFF	0.0	0.12000E+04	0.40000E+04	0.20000E+03	0.0	0.0
19	0	18	11	0	1	0	9	ON	0.19282E-01	0.10000E-03	0.99000E+00	0.50000E-01	0.50000E-01	-0.11548E-06
20	15	0	10	1	0	0	5	OFF	0.0	0.10000E+00	0.30000E+01	0.30000E+03	0.0	0.0
21	15	0	1	1	0	0	1	OFF	0.0	0.50000E+00	0.10000E+02	0.30000E+03	0.0	0.0
22	11	0	11	2	0	0	3	OFF	0.0	0.0	0.10000E+00	0.33000E-01	0.0	0.0
23	12	0	12	2	0	0	3	OFF	0.0	0.0	0.10000E+00	0.10000E-01	0.0	0.0
25	24	0	10	1	0	0	7	OFF	0.0	0.10000E+00	0.20000E+01	0.0	0.0	0.0
27	26	0	26	2	0	0	3	OFF	0.0	0.0	0.10000E+00	0.60000E-02	0.0	0.0
28	9	0	9	2	0	0	3	OFF	0.0	0.0	0.10000E+00	0.10000E-01	0.0	0.0

SCHED	REFERENCE NOS. SCHDVAR CPT	SCHDVAR STA	ARG1 CPT	ARG1 STA	ARG2 CPT	ARG2 STA	VARIABLE NOS. DAT	SCHDVAR VAR	SCHDVAR STA	ARG1 VAR	ARG1 STA	ARG2 VAR	ARG2 STA	SCHDVAR ACT	SCHDVAR TBL	ARG1 ACT	ARG1 TBL	ARG2 ACT	ARG2 TBL
24	10	0	15	0	0	0	0	6	0	1	0	0	0	0.86800E+00	0.86500E+00	0.30000E+03	0.30000E+03	0.0	0.0

OVERALL ENGINE PERFORMANCE DATA

AIR,LB/SEC	FUEL,LB/HR	GRS.JET THT	NET JET THT	PROP.THRUST	*TOT.NET THT	FUEL/TOTTHT	TOTTHT/AIR	OVERBD BLEED
0.26331E+01	0.14062E+03	0.20955E+02	0.20955E+02	0.0	0.20955E+02	0.67106E+01	0.79584E+01	0.12899E+00

BRAKE SH.HP	PROP. HP	*TOT.SHFT HP	FUEL/TOTSHP	TOTSHP/AIR	EQUIV.SH.HP	FUEL/ESHP	ESHP/AIR
0.30000E+03	0.0	0.30000E+03	0.46873E+00	0.11394E+03	0.30000E+03	0.46873E+00	0.11394E+03

98 REGEN. PROP. ENG. INSTALLED 12/9/80 POINT FIIS

COMPONENT PERFORMANCE DATA COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT COMPONENT ERROR SIGNAL = 0

STATION	WTFLOW	TOPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
1	0.29115E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.45120E+01	0.0	0.0
2	0.29115E+01	0.14588E+02	0.51869E+03	0.10000E+01	0.0	0.45453E+01	0.0	0.0
3	0.25475E+01	0.12166E+03	0.10536E+04	0.20313E+01	0.0	0.67970E+00	0.0	0.0
4	0.36393E+00	0.0	0.10536E+04	0.20313E+01	0.0	0.0	0.0	0.0
5	0.25475E+01	0.11984E+03	0.10536E+04	0.20313E+01	0.0	0.69004E+00	0.0	0.0
6	0.25476E+01	0.11984E+03	0.15109E+04	0.29129E+01	0.0	0.82633E+00	0.0	0.0
7	0.25476E+01	0.11808E+03	0.15109E+04	0.29129E+01	0.0	0.83856E+00	0.0	0.0
8	0.25939E+01	0.11395E+03	0.26063E+04	0.50248E+01	0.18160E-01	0.11622E+01	0.0	0.0
9	0.27045E+01	0.11395E+03	0.25482E+04	0.49127E+01	0.17405E-01	0.11981E+01	0.0	0.0
10	0.28705E+01	0.37662E+02	0.19925E+04	0.38415E+01	0.16382E-01	0.34021E+01	0.0	0.0
11	0.28705E+01	0.37662E+02	0.19925E+04	0.38415E+01	0.16382E-01	0.34021E+01	0.0	0.0
12	0.28705E+01	0.15830E+02	0.16584E+04	0.31974E+01	0.16382E-01	0.73843E+01	0.0	0.0
13	0.28205E+01	0.15200E+02	0.16584E+04	0.31974E+01	0.16382E-01	0.75567E+01	0.0	0.0
14	0.28206E+01	0.15200E+02	0.12639E+04	0.24368E+01	0.16382E-01	0.65972E+01	0.0	0.0
15	0.28232E+01	0.15010E+02	0.12639E+04	0.24368E+01	0.16382E-01	0.66868E+01	0.19246E+00	0.14696E+02
16	0.28232E+01	0.15004E+02	0.12639E+04	0.24368E+01	0.16382E-01	0.66897E+01	0.19053E+00	0.14696E+02
17	0.29115E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.45120E+01	0.0	0.0
18	0.49990E-01	0.15200E+02	0.16584E+04	0.31974E+01	0.16382E-01	0.13394E+00	0.0	0.0

375 hp
Installed

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 17 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.53724E+03	0.87324E+02	0.83396E+01	0.79370E+00	0.12500E+00	0.14349E+01	0.49809E+05	0.89130E+01	0.37935E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.14974E-01	0.0	0.0	0.32412E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.14692E-01	0.0	0.0	0.21517E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30400E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 18	0.39830E-01	0.0	0.0	0.73046E-03	0.0	0.0	0.0	0.0	0.17416E-01
12	14 0 15 0	0.12467E-01	0.0	0.0	0.28645E-03	0.0	0.0	0.0	0.0	0.0
26	17 0 2 0	0.73350E-02	0.0	0.0	0.36034E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.26063E+04	0.10954E+04	0.35000E-01	0.16656E+03	0.99000E+00	0.0	0.13175E+07	0.25596E+06	0.14136E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.56124E+03	0.87384E+02	0.30255E+01	0.86300E+00	0.45600E+00	0.0	0.10108E+01	0.30255E+01	0.35630E+01
10	11 4 12 0	0.38061E+03	0.20000E+05	0.23791E+01	0.88000E+00	0.0	0.0	0.98559E+00	0.23791E+01	0.35630E+01

```
HT EX  STATIONS     JP1 TEMP    JP2 TEMP    JM1 CORFLO  JM2 CORFLO  JM1 DELP/PT JM2 DELP/PT EFFECTVNESS EFFT SCL F.  LIMIT IND
  4   5 13  6 14   0.15112E+04 0.12637E+04 0.69004E+00 0.75567E+01 0.0         0.0         0.75650E+00 0.75650E+00 0.0

NOZZL  STATIONS    GRSS THRUST NOZZLE AREA ACT JET VEL IDL JET VEL IDL VEL PR   PTIN/PAMB  DISCHG COEF  VEL COEF   NOZZLE TYPE
 13  15  0 16  0   0.26432E+02 0.42360E+02 0.30123E+03 0.30427E+03 0.10214E+01 0.10214E+01 0.10000E+01 0.99000E+00    CONV

SHAFT COMPONENTS      NET HP     ACTUAL RPM JM1 MCH EFF JM2 MCH EFF JP1 MCH EFF JP2 MCH EFF    TORQUE     NON-TURB HP SUM ABS HP/2
 14   8  0  2 18  -0.85907E-02 0.87384E+02 0.99500E+00 0.0         0.10000E+01 0.10000E+01-0.51634E+00-0.55844E+03 0.55844E+03
 15  10  0  0  0   0.37490E+03 0.20000E+05 0.98500E+00 0.0         0.0         0.0         0.98450E+02 0.0         0.18745E+03

LOAD                HORSEPOWER  HP FACTOR   ACTUAL RPM  RPM FACTOR
 18               -0.21200E+02 0.21200E+02 0.87384E+02 0.10000E+01

CONTR  REFERENCE NOS.     VARIABLE NOS.
       DEPEND  INDEP       DEPEND     INDEP
       CPT STA  CPT      VAR STA PER  DAT    CONTR SWITCH  INDEP VAR   MIN LIMIT   MAX LIMIT   DEPEND DES ABS DEP ACT  DEPEND ERR
 16     14   0   14       1   0   0    1         ON       0.87384E+02 0.40000E+02 0.11500E+03 0.0         0.55844E+03-0.85907E-02
 17     15   0    6       1   0   0    4         OFF      0.0         0.12000E+04 0.40000E+04 0.37500E+03 0.0         0.0
 19      0  18   11       0   1   0    9         ON       0.17416E-01 0.10000E-03 0.99000E+00 0.50000E-01 0.49992E-01-0.84899E-05
 20     15   0   10       1   0   0    5         ON       0.95485E+00 0.10000E+00 0.30000E+01 0.37500E+03 0.18745E+03-0.10490E+00
 21     15   0    1       1   0   0    1         OFF      0.0         0.50000E+00 0.10000E+02 0.30000E+03 0.0         0.0
 22     11   0   11       2   0   0    3         OFF      0.0         0.0         0.10000E+00 0.33000E-01 0.0         0.0
 23     12   0   12       2   0   0    3         OFF      0.0         0.0         0.10000E+00 0.10000E-01 0.0         0.0
 25     24   0   10       1   0   0    7         OFF      0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0
 27     26   0   26       2   0   0    3         OFF      0.0         0.0         0.10000E+00 0.60000E-02 0.0         0.0
 28      9   0    9       2   0   0    3         OFF      0.0         0.0         0.10000E+00 0.10000E-01 0.0         0.0

SCHED      REFERENCE NOS.              VARIABLE NOS.
      SCHDVAR   ARG1     ARG2      SCHDVAR     ARG1     ARG2
      CPT STA CPT STA CPT STA    DAT VAR STA VAR STA VAR STA  SCHDVAR ACT SCHDVAR TBL  ARG1 ACT    ARG1 TBL    ARG2 ACT    ARG2 TBL
 24   10   0  15   0   0   0      0   8   0   1   0   0   0   0.88000E+00 0.87998E+00 0.37490E+03 0.37490E+03 0.0         0.0

                 OVERALL ENGINE PERFORMANCE DATA

            AIR,LB/SEC   FUEL,LB/HR   GRS.JET THT  NET JET THT  PROP.THRUST *TOT.NET THT  FUEL/TOTTHT  TOTTHT/AIR  OVERBRD BLEED
            0.29115E+01  0.16656E+03  0.26432E+02  0.26432E+02  0.0          0.26432E+02  0.63013E+01  0.90737E+01  0.13734E+00

            BRAKE SH.HP  PROP. HP    *TOT.SHFT HP  FUEL/TOTSHP  TOTSHP/AIR   EQUIV.SH.HP  FUEL/ESHP    ESHP/AIR
            0.37490E+03  0.0          0.37490E+03  0.44428E+00  0.12876E+03  0.37490E+03  0.44428E+00  0.12876E+03
```

93 REGEN. PROP. ENG. INSTALLED 12/9/80 POINT FIIS

COMPONENT PERFORMANCE DATA   COMPONENT INTERFACE TOLERANCE = 0.0100 PERCENT   COMPONENT ERROR SIGNAL = 0

	STATION	WTFLOW	TOTPRES	TOTEMP	THETA	FUEL/AIR	CORFLO	VMACH	STPRES
	1	0.35578E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.55137E+01	0.0	0.0
	2	0.35578E+01	0.14535E+02	0.51869E+03	0.10000E+01	0.0	0.55747E+01	0.0	0.0
	3	0.31131E+01	0.15302E+03	0.11404E+04	0.21986E+01	0.0	0.68705E+00	0.0	0.0
	4	0.44473E+00	0.0	0.11404E+04	0.21986E+01	0.0	0.0	0.0	0.0
	5	0.31131E+01	0.15068E+03	0.11404E+04	0.21986E+01	0.0	0.69772E+00	0.0	0.0
	6	0.31131E+01	0.15068E+03	0.15614E+04	0.30103E+01	0.0	0.81642E+00	0.0	0.0
	7	0.31131E+01	0.14851E+03	0.15614E+04	0.30103E+01	0.0	0.82830E+00	0.0	0.0
4.0	8	0.31756E+01	0.14332E+03	0.27500E+04	0.53018E+01	0.19988E-01	0.11620E+01	0.0	0.0
4.1	9	0.33108E+01	0.14332E+03	0.26900E+04	0.51861E+01	0.19156E-01	0.11981E+01	0.0	0.0
	10	0.35135E+01	0.42168E+02	0.20644E+04	0.39800E+01	0.18030E-01	0.37857E+01	0.0	0.0
	11	0.35135E+01	0.42168E+02	0.20644E+04	0.39800E+01	0.18030E-01	0.37857E+01	0.0	0.0
4.5	12	0.35135E+01	0.16441E+02	0.17035E+04	0.32842E+01	0.18030E-01	0.83200E+01	0.0	0.0
	13	0.34635E+01	0.15507E+02	0.17035E+04	0.32842E+01	0.18030E-01	0.92183E+01	0.0	0.0
	14	0.34635E+01	0.15507E+02	0.13423E+04	0.25880E+01	0.18030E-01	0.81833E+01	0.0	0.0
	15	0.34627E+01	0.15210E+02	0.13423E+04	0.25880E+01	0.18030E-01	0.83412E+01	0.24279E+00	0.14696E+02
	16	0.34627E+01	0.151[illegible]E+02	0.13423E+04	0.25880E+01	0.18030E-01	0.83469E+01	0.24036E+00	0.14696E+02
	17	0.35578E+01	0.14696E+02	0.51869E+03	0.10000E+01	0.0	0.55137E+01	0.0	0.0
	18	0.49980E-01	0.15507E+02	0.17035E+04	0.32842E+01	0.18030E-01	0.13303E+00	0.0	0.0

500 hp
IRP
Installed

INLET	STATIONS	RAM DRAG	FLT VEL KTS	AMB TEMP	AMB PRESS	EFFICIENCY	RECOVERY	ALTITUDE	THETA RAM	DELTA RAM
1	1 0 17 0	0.0	0.0	0.51869E+03	0.14696E+02	0.10000E+01	0.10000E+01	0.0	0.10000E+01	0.10000E+01

COMPR	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	JP2 BLDFRAC	TABLE R	TABLE CORRPM	TABLE PR	TABLE CORFLO
2	2 0 3 4	-0.76640E+03	0.94123E+02	0.10527E+02	0.78242E+00	0.12500E+00	0.15712E+01	0.53650E+05	0.11272E+02	0.46551E+01

DUCT	STATIONS	DELTA P/PT	C1 FACTOR	C2 FACTOR	C3 FACTOR	TBIN2-TBIN1	TBIN2	WBIN2/WBIN	WBIN/WBAV	WBOUT/WDUCT
3	3 0 5 0	0.15300E-01	0.0	0.0	0.32412E-01	0.0	0.0	0.0	0.0	0.0
5	6 0 7 0	0.14342E-01	0.0	0.0	0.21517E-01	0.0	0.0	0.0	0.0	0.0
7	8 4 9 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30400E+00	0.0
9	10 4 11 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	12 0 13 18	0.56824E-01	0.0	0.0	0.73046E-03	0.0	0.0	0.0	0.0	0.14225E-01
12	14 0 15 0	0.19182E-01	0.0	0.0	0.28645E-03	0.0	0.0	0.0	0.0	0.0
26	17 0 2 0	0.10954E-01	0.0	0.0	0.36034E-03	0.0	0.0	0.0	0.0	0.0

BURNR	STATIONS	EXIT TEMP	TEMP RISE	DELTA P/PT	FUEL FLOW	EFFICIENCY	BURNR THETA	COMB LDG 1	COMB LDG 2	COMB LDG 3
6	7 0 8 0	0.27500E+04	0.11886E+04	0.35000E-01	0.22401E+03	0.99000E+00	0.0	0.14088E+07	0.22781E+06	0.10911E+00

TURBN	STATIONS	HORSEPOWER	ACTUAL RPM	PRESS RATIO	ADIAB EFF	WBIN/WBTOT	WBSTAT/WBIN	TABLE CORRPM	TABLE PR	TABLE CORFLO
8	9 4 10 0	0.79174E+03	0.94123E+02	0.33987E+01	0.86300E+00	0.45600E+00	0.0	0.10597E+01	0.33937E+01	0.35630E+01
10	11 4 12 0	0.50748E+03	0.20000E+05	0.25648E+01	0.85800E+00	0.0	0.0	0.96829E+00	0.25648E+01	0.35630E+01

```
HT EX  STATIONS      JP1 TEMP    JP2 TEMP    JM1 CORFLO  JM2 CORFLO JM1 DELP/PT JM2 DELP/PT EFFECTVNESS EFFT SCL F.  LIMIT IND
  4    5 13  6 14   0.15616E+04 0.13425E+04 0.69772E+00 0.92183E+01 0.0         0.0         0.74800E+00 0.74800E+00 0.0

NOZZL  STATIONS     GRSS THRUST NOZZLE AREA ACT JET VEL IDL JET VEL IDL VEL FR   PTIN/PAMB  DISCHG COEF  VEL COEF   NOZZLE TYPE
 13  15  0 16  0    0.42096E+02 0.42350E+02 0.39113E+03 0.39508E+03 0.10350E+01 0.10350E+01 0.10000E+01 0.99000E+00    CONV

SHAFT COMPONENTS      NET HP     ACTUAL RPM JM1 MCH EFF JM2 MCH EFF JP1 MCH EFF JP2 MCH EFF   TORQUE    NON-TURB HP SUM ABS HP/2
 14   8  0  2 18    0.18203E+00 0.94123E+02 0.99500E+00 0.0         0.10000E+01 0.10000E+01 0.10160E+02-0.78760E+03 0.78769E+03
 15  10  0  0  0    0.49987E+03 0.20000E+05 0.93500E+00 0.0         0.0         0.0         0.13127E+03 0.0         0.24993E+03

LOAD                 HORSEPOWER  HP FACTOR   ACTUAL RPM  RPM FACTOR
 18                -0.21200E+02 0.21200E+02 0.94123E+02 0.10000E+01

CONTR  REFERENCE NOS.    VARIABLE NOS.
       DEPEND  INDEP      DEPEND     INDEP
       CPT STA  CPT     VAR STA PER   DAT   CONTR SWITCH  INDEP VAR   MIN LIMIT   MAX LIMIT   DEPEND DES ABS DEP ACT  DEPEND ERR
 16     14   0   14      1   0   0     1        ON      0.94123E+02 0.40000E+02 0.11500E+03 0.0         0.78769E+03 0.18208E+00
 17     15   0    6      1   0   0     4        OFF     0.0         0.12000E+04 0.40000E+04 0.50000E+03 0.0         0.0
 19      0  18   11      0   1   0     9        ON      0.14225E-01 0.10000E-03 0.99000E+00 0.50000E-01 0.49900E-01-0.19655E-04
 20     15   0   10      1   0   0     5        ON      0.10625E+01 0.10000E+00 0.30000E+01 0.50000E+03 0.24993E+03-0.13403E+00
 21     15   0    1      1   0   0     1        OFF     0.0         0.50000E+00 0.10000E+02 0.30000E+03 0.0         0.0
 22     11   0   11      2   0   0     3        OFF     0.0         0.0         0.10000E+00 0.33000E-01 0.0         0.0
 23     12   0   12      2   0   0     3        OFF     0.0         0.0         0.10000E+00 0.10000E-01 0.0         0.0
 25     24   0   10      1   0   0     7        OFF     0.0         0.10000E+00 0.20000E+01 0.0         0.0         0.0
 27     26   0   26      2   0   0     3        OFF     0.0         0.0         0.10000E+00 0.60000E-02 0.0         0.0
 28      9   0    9      2   0   0     3        OFF     0.0         0.0         0.10000E+00 0.10000E-01 0.0         0.0

SCHED      REFERENCE NOS.               VARIABLE NOS.
      SCHDVAR   ARG1    ARG2      SCHDVAR     ARG1     ARG2
      CPT STA CPT STA CPT STA   DAT VAR STA VAR STA VAR STA  SCHDVAR ACT SCHDVAR TBL  ARG1 ACT     ARG1 TBL    ARG2 ACT     ARG2 TBL
 24    10   0  15   0   0   0     0   8   0   1   0   0   0  0.85800E+00 0.86000E+00 0.49987E+03 0.49987E+03 0.0          0.0

                OVERALL ENGINE PERFORMANCE DATA

            AIR,LB/SEC   FUEL,LB/HR   GRS.JET THT  NET JET THT  PROP.THRUST *TOT.NET THT  FUEL/TOTTHT  TOTTHT/AIR  OVERBRD BLEED
            0.35578E+01  0.22401E+03  0.42096E+02  0.42096E+02  0.0          0.42096E+02  0.53213E+01  0.11832E+02  0.15672E+00

            BRAKE SH.HP  PROP. HP    *TOT.SHFT HP  FUEL/TOTSHP  TOTSHP/AIR   EQUIV.SH.HP  FUEL/ESHP    ESHP/AIR
            0.49987E+03  0.0          0.49987E+03  0.44813E+00  0.14050E+03  0.49987E+03  0.44813E+00  0.14050E+03
```

APPENDIX D: SELECTED CYCLE RECUPERATOR DATA AND OFF-DESIGN PERFORMANCE

a) Selected Cycle Recuperator Data

OD = 23.5 in.

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=F ,E/D=.105, FPL=3.5 CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	6.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	22.98	XMD	19.99	AS	111.82	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.00	XOD	23.54	FAR	4.71										
E	0.7092	PDT	0.59	WT1	2.096	P1T	7.250	P2T	7.21	T1T	558.8	RET	3559.6	HT	89.0
CC	0.8624	PDS	4.98	WS1	2.360	P1S	1.074	P2S	1.02	T1S	1184.0	RES	718.9	HS	86.8
CMIN	TUBE	PD	5.58	NTU	2.474			T2T	1002.4	T2S	801.6	UA	4779.9	U	42.7

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=F ,E/D=.105, FPL=3.5 CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	8.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	28.88	XMD	19.99	AS	149.09	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.26	XOD	23.54	FAR	6.27										
E	0.7400	PDT	0.78	WT1	2.096	P1T	7.250	P2T	7.19	T1T	558.8	RET	3540.3	HT	89.1
CC	0.8643	PDS	3.02	WS1	2.360	P1S	1.052	P2S	1.02	T1S	1184.0	RES	541.6	HS	72.8
CMIN	TUBE	PD	3.80	NTU	3.012			T2T	1021.4	T2S	784.2	UA	5827.0	U	39.1

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=F ,E/D=.105, FPL=3.5 CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	10.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	34.78	XMD	19.99	AS	186.36	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.52	XOD	23.54	FAR	7.84										
E	0.7593	PDT	0.96	WT1	2.096	P1T	7.250	P2T	7.18	T1T	558.8	RET	3528.2	HT	89.2
CC	0.8655	PDS	2.03	WS1	2.360	P1S	1.041	P2S	1.02	T1S	1184.0	RES	434.5	HS	63.6
CMIN	TUBE	PD	3.00	NTU	3.492			T2T	1033.5	T2S	773.1	UA	6759.6	U	36.3

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=F ,E/D=.105, FPL=3.5 CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	12.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	40.68	XMD	19.99	AS	223.63	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.78	XOD	23.54	FAR	9.41										
E	0.7725	PDT	1.15	WT1	2.096	P1T	7.250	P2T	7.17	T1T	558.8	RET	3520.0	HT	89.2
CC	0.8663	PDS	1.47	WS1	2.360	P1S	1.035	P2S	1.02	T1S	1184.0	RES	362.8	HS	57.0
CMIN	TUBE	PD	2.62	NTU	3.927			T2T	1041.7	T2S	765.6	UA	7606.5	U	34.0

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=F ,E/D=.105, FPL=3.5 CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	14.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	46.58	XMD	19.99	AS	260.90	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	2.04	XOD	23.54	FAR	10.98										
E	0.7818	PDT	1.34	WT1	2.096	P1T	7.250	P2T	7.15	T1T	558.8	RET	3514.2	HT	89.2
CC	0.8669	PDS	1.11	WS1	2.360	P1S	1.031	P2S	1.02	T1S	1184.0	RES	311.4	HS	51.9
CMIN	TUBE	PD	2.45	NTU	4.328			T2T	1047.6	T2S	760.3	UA	8386.0	U	32.1

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=F ,E/D=.105, FPL=3.5 CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	16.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	52.48	XMD	19.99	AS	298.18	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	2.30	XOD	23.54	FAR	12.55										
E	0.7888	PDT	1.53	WT1	2.096	P1T	7.250	P2T	7.14	T1T	558.8	RET	3509.9	HT	89.2
CC	0.8674	PDS	0.87	WS1	2.360	P1S	1.029	P2S	1.02	T1S	1184.0	RES	272.8	HS	47.9
CMIN	TUBE	PD	2.40	NTU	4.701			T2T	1051.9	T2S	756.3	UA	9110.6	U	30.6

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG CYL=F ,E/D=.105, FPL=3.5 CORE LENGTH=6,8,10,12,14,16,18 2PASS A

LGT	18.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	58.39	XMD	19.99	AS	335.45	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	2.55	XOD	23.54	FAR	14.12										
E	0.7941	PDT	1.71	WT1	2.096	P1T	7.250	P2T	7.13	T1T	558.8	RET	3506.6	HT	89.3
CC	0.8677	PDS	- 0.71	WS1	2.360	P1S	1.027	P2S	1.02	T1S	1184.0	RES	242.6	HS	44.6
CMIN	TUBE	PD	2.42	NTU	5.050			T2T	1055.2	T2S	753.2	UA	9789.7	U	29.2

b) Recuperator Off-Design Performance

50 hp

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG FINAL CYCLE ,E/D=.105,OFF DESIGN POINTS 2PASS A

LGT	10.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	34.78	XMD	19.99	AS	186.36	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.52	XOD	23.54	FAR	7.84										
E	0.7646	PDT	1.16	WT1	1.231	P1T	3.523	P2T	3.48	T1T	357.1	RET	2429.9	HT	50.7
CC	0.8775	PDS	0.61	WS1	1.376	P1S	1.012	P2S	1.01	T1S	826.0	RES	301.4	HS	41.6
CMIN	TUBE	PD	1.77	NTU	3.768			T2T	715.6	T2S	511.4	UA	4151.9	U	22.3

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG FINAL CYCLE ,E/D=.105,OFF DESIGN POINTS 2PASS A

150 hp

LGT	10.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	34.78	XMD	19.99	AS	186.36	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.52	XOD	23.54	FAR	7.84										
E	0.7611	PDT	1.04	WT1	1.716	P1T	5.473	P2T	5.42	T1T	477.2	RET	3088.0	HT	72.0
CC	0.8708	PDS	1.28	WS1	1.926	P1S	1.026	P2S	1.01	T1S	1015.9	RES	382.3	HS	53.9
CMIN	TUBE	PD	2.33	NTU	3.589			T2T	887.2	T2S	658.9	UA	5609.4	U	30.1

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG FINAL CYCLE ,E/D=.105,OFF DESIGN POINTS 2PASS A

300 hp
60% IRP

LGT	10.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	34.78	XMD	19.99	AS	186.36	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.52	XOD	23.54	FAR	7.84										
E	0.7593	PDT	0.96	WT1	2.096	P1T	7.250	P2T	7.18	T1T	558.8	RET	3528.2	HT	89.2
CC	0.8655	PDS	2.03	WS1	2.360	P1S	1.041	P2S	1.02	T1S	1184.0	RES	434.5	HS	63.6
CMIN	TUBE	PD	3.00	NTU	3.492			T2T	1033.5	T2S	773.1	UA	6759.6	U	36.3

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG FINAL CYCLE ,E/D=.105,OFF DESIGN POINTS 2PASS A

400 hp

LGT	10.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	34.78	XMD	19.99	AS	186.36	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.52	XOD	23.54	FAR	7.84										
E	0.7554	PDT	0.94	WT1	2.438	P1T	8.633	P2T	8.55	T1T	612.2	RET	4010.3	HT	104.1
CC	0.8652	PDS	2.70	WS1	2.749	P1S	1.055	P2S	1.03	T1S	1208.2	RES	497.2	HS	70.4
CMIN	TUBE	PD	3.63	NTU	3.381			T2T	1062.4	T2S	818.7	UA	7653.4	U	41.1

CROSS-FLOW HEAT EXCHANGER CALCULATION- AIR IN STAGGERED DIMPLED TUBES 1
REG ENG FINAL CYCLE ,E/D=.105,OFF DESIGN POINTS 2PASS A

500 hp
IRP

LGT	10.00	XID	16.44	N	5695.00	XT	1.250	DTO	0.1500	PSTU	2.0	DHT	0.01183	SIGT	0.5630
WGT	34.78	XMD	19.99	AS	186.36	XL	1.000	WALL	0.0040	PSSH	1.0	DHS	0.00398	SIGS	0.2000
VOL	1.52	XOD	23.54	FAR	7.84										
E	0.7480	PDT	0.93	WT1	2.892	P1T	10.472	P2T	10.38	T1T	687.0	RET	4610.0	HT	118.1
CC	0.8652	PDS	3.71	WS1	3.265	P1S	1.077	P2S	1.04	T1S	1243.0	RES	576.2	HS	79.2
CMIN	TUBE	PD	4.63	NTU	3.196			T2T	1102.9	T2S	883.2	UA	8641.0	U	46.4

APPENDIX E: FLOW CONDITIONS, GAS PRODUCER TURBINE AND TRANSITION DUCT

REGENERATIVE ENGINE STUDY GPT

NO. OF STATIONS = 14   NO. OF STREAMLINES = 11   INLET WF/WA = 0.01920   EXIT OF INLET GUIDE VANE = STATION 5   PLOT

1 SPOOL   SPOOL STATIONS: 4 - 7

INPUT IS IN MKS UNITS   DISTANCES ARE IN METERS, VELOCITIES ARE M./SEC.

Pressures in bar
Temperatures in K

1 bar = 14.5 psi
1 K = 1.8°R

INPUT TO AXIAL STATION 1 - STATOR

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0670	-0.0300	0.0840	-0.0300	0.3000	1.3766	66280.0

TOT PRESS	10.259	10.259	10.259	10.259	10.259	10.259	10.259	10.259	10.259	10.259	10.259
TOT TEMP	1393.70	1435.70	1471.70	1498.70	1517.70	1528.70	1531.70	1526.70	1513.70	1492.70	1463.70
VU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INPUT TO AXIAL STATION 2 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0670	-0.0200	0.0820	-0.0200	0.3000	1.3766	66280.0

INPUT TO AXIAL STATION 3 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0670	-0.0100	0.0800	-0.0100	0.3000	1.3766	66280.0

INPUT TO AXIAL STATION 4 - DUMMY

Stator Entrance

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0670	0.0	0.0780	0.0	0.3000	1.3766	66280.0

INPUT TO AXIAL STATION 5 - STATOR

Stator Exit
Rotor Inlet

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0640	0.0200	0.0740	0.0200	1.0000	1.3766	66280.0

TOT PRESS	9.823	9.823	9.823	9.823	9.823	9.823	9.823	9.823	9.823	9.823	9.823
VU	785.80	788.10	788.60	786.40	781.90	775.30	766.60	756.00	743.60	729.40	713.40

```
                                                  INPUT TO AXIAL STATION  6 - ROTOR                        Rotor Exit
HUB RADIUS    HUB STATION    TIP RADIUS    TIP STATION    MACH NO.    MASS FLOW      RPM
    0.0610         0.0400        0.0740         0.0400      0.5000       1.4591   66280.0

DELTA H    84.82   87.43   89.59   91.22   92.40   93.05   93.25   92.95   92.17   90.88   89.12
ETA POLY   0.8760  0.8760  0.8760  0.8760  0.8760  0.8760  0.8760  0.8760  0.8760  0.8760  0.8760

                                                  INPUT TO AXIAL STATION  7 - DUMMY                        Transition Duct
HUB RADIUS    HUB STATION    TIP RADIUS    TIP STATION    MACH NO.    MASS FLOW      RPM
    0.0595         0.0500        0.0745         0.0500      0.4[illegible]       1.4591   66280.0

                                                  INPUT TO AXIAL STATION  8 - DUMMY
HUB RADIUS    HUB STATION    TIP RADIUS    TIP STATION    MACH NO.    MASS FLOW      RPM
    0.0595         0.0600        0.0760         0.0600      0.4000       1.4591       0.0

                                                  INPUT TO AXIAL STATION  9 - DUMMY
HUB RADIUS    HUB STATION    TIP RADIUS    TIP STATION    MACH NO.    MASS FLOW      RPM
    0.0615         0.0700        0.0790         0.0700      0.3900       1.4591       0.0

                                                  INPUT TO AXIAL STATION 10 - DUMMY
HUB RADIUS    HUB STATION    TIP RADIUS    TIP STATION    MACH NO.    MASS FLOW      RPM
    0.0660         0.0800        0.0840         0.0800      0.3800       1.4591       0.0

                                                  INPUT TO AXIAL STATION 11 - DUMMY
HUB RADIUS    HUB STATION    TIP RADIUS    TIP STATION    MACH NO.    MASS FLOW      RPM
    0.0720         0.0900        0.0890         0.0900      0.3700       1.4591       0.0

                                                  INPUT TO AXIAL STATION 12 - DUMMY                        Transition Duct
HUB RADIUS    HUB STATION    TIP RADIUS    TIP STATION    MACH NO.    MASS FLOW      RPM
    0.0771         0.1000        0.0940         0.1000      0.3600       1.4591       0.0

                                                  INPUT TO AXIAL STATION 13 - DUMMY
HUB RADIUS    HUB STATION    TIP RADIUS    TIP STATION    MACH NO.    MASS FLOW      RPM
    0.0806         0.1100        0.0980         0.1100      0.3500       1.4591       0.0

                                                  INPUT TO AXIAL STATION 14 - DUMMY
HUB RADIUS    HUB STATION    TIP RADIUS    TIP STATION    MACH NO.    MASS FLOW      RPM
    0.0824         0.1200        0.1005         0.1200      0.3500       1.4591       0.0

STREAMLINE DEFINITION:  0.0   0.100  0.200  0.300  0.400  0.500  0.600  0.700  0.800  0.900  1.000
```

STATION NUMBER 4 DOWNSTREAM OF REMOTE

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.06700	718.95093	89.99997	89.99997	720.26538	165.94582	165.92873	116.56059	116.56059	-5.85546
0.06812	729.07080	89.99997	89.99997	730.38062	166.05264	166.02139	117.69130	117.69130	-8.03048
0.06923	737.59448	89.99997	89.99997	738.89355	166.18849	166.13959	118.57281	118.57281	-10.15339
0.07035	743.90356	89.99997	89.99997	745.19458	166.36629	166.29672	119.06837	119.06837	-12.21149
0.07147	748.30566	89.99997	89.99997	749.58569	166.57819	166.48552	119.22733	119.22733	-14.19655
0.07258	750.84448	89.99997	89.99997	752.11304	166.82243	166.70464	119.04526	119.04526	-16.09866
0.07368	751.54492	89.99997	89.99997	752.80078	167.09630	166.95145	118.53241	118.53241	-17.91370
0.07478	750.41284	89.99997	89.99997	751.65454	167.39722	167.22394	117.69701	117.69701	-19.63417
0.07587	747.43921	89.99997	89.99997	748.66382	167.72791	167.52524	116.49715	116.49715	-21.23932
0.07694	742.59253	89.99997	89.99997	743.80005	168.08324	167.85046	114.96906	114.96906	-22.72466
0.07800	735.82764	89.99997	89.99997	737.01367	168.46632	168.20334	113.06815	113.06815	-24.06721

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	116.41342	0.0	479.42041	-465.03516	0.16213	0.16192	0.66683	0.16213
0.00112	10.14310	117.41701	0.0	487.21411	-472.78589	0.16143	0.16105	0.66827	0.16143
0.00223	20.31134	118.13730	0.0	494.96606	-480.55371	0.16076	0.16017	0.67105	0.16076
0.00335	30.47968	118.44052	0.0	502.62549	-488.31885	0.16006	0.15921	0.67566	0.16006
0.00447	40.62512	118.37910	0.0	510.19238	-496.06567	0.15933	0.15820	0.68180	0.15933
0.00558	50.72842	117.95171	0.0	517.65308	-503.77881	0.15855	0.15709	0.68943	0.15855
0.00668	60.77078	117.17094	0.0	525.00000	-511.44434	0.15772	0.15591	0.69856	0.15772
0.00778	70.73482	116.04776	0.0	532.22632	-519.04932	0.15684	0.15465	0.70924	0.15684
0.00887	80.60463	114.54465	0.0	539.31494	-526.58252	0.15586	0.15325	0.72155	0.15586
0.00994	90.36496	112.70082	0.0	546.26660	-534.03125	0.15482	0.15177	0.73562	0.15482
0.01100	100.00000	110.47702	0.0	553.06567	-541.38452	0.15366	0.15014	0.75162	0.15366

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.0	465.03516	10.08602	1388.29272	10.25900	1393.69995	0.0	-2.87949	-8.25385	2.5297832
0.00000	472.78589	10.08779	1430.22070	10.25900	1435.69995	9.45169	-3.91253	-7.03353	2.4560547
0.00000	480.55371	10.08946	1466.16846	10.25900	1471.69995	9.63153	-4.91225	-5.92407	2.3962317
0.00000	488.31885	10.09111	1493.14502	10.25900	1498.69995	9.78895	-5.88653	-4.91857	2.3533239
0.00000	496.06567	10.09276	1512.14624	10.25900	1517.69995	9.92278	-6.83851	-4.01247	2.3241329
0.00000	503.77881	10.09445	1523.17261	10.25900	1528.69995	10.03722	-7.77201	-3.19884	2.3076944
0.00000	511.44434	10.09617	1526.22266	10.25900	1531.69995	10.12971	-8.69237	-2.47455	2.3034763
0.00000	519.04932	10.09793	1521.29541	10.25900	1526.69995	10.20259	-9.60296	-1.83583	2.3113365
0.00000	526.58252	10.09982	1508.39453	10.25900	1513.69995	10.25373	-10.50471	-1.27846	2.3315420
0.00000	534.03125	10.10178	1487.51636	10.25900	1492.69995	10.28597	-11.40010	-0.79743	2.3647261
0.0	541.38452	10.10390	1458.66406	10.25900	1463.69995	10.29578	-12.28977	-0.39075	2.4120083

STATION NUMBER 5 DOWNSTREAM OF NOZZLE 1

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.06400	647.65259	19.29176	19.03479	720.26538	38.43788	38.84209	832.54907	275.05664	-46.44614
0.06507	659.11279	19.26671	19.03839	730.38062	38.95067	39.31129	834.85815	275.47485	-43.89240
0.06614	669.01318	19.25204	19.04855	738.89355	39.56499	39.88774	835.31299	275.42310	-41.45929
0.06719	676.79004	19.25768	19.07552	745.19458	40.35335	40.64343	833.01123	274.74146	-39.13870
0.06822	682.79736	19.26909	19.10539	749.58569	41.29207	41.55370	828.30200	273.34399	-36.91660
0.06924	686.96582	19.28516	19.13741	752.11304	42.39175	42.62862	821.39136	271.28101	-34.80626
0.07024	689.30615	19.33002	19.19585	752.80078	43.71945	43.93469	812.39673	268.91064	-32.85320
0.07121	689.81860	19.38091	19.25845	751.65454	45.26152	45.45760	801.41357	265.94653	-31.01074
0.07217	688.49146	19.42781	19.31549	748.66382	47.03807	47.21704	788.49609	262.26880	-29.26390
0.07309	685.29907	19.47363	19.37007	743.80005	49.10831	49.27165	773.65698	257.91650	-27.60909
0.07400	680.19800	19.52304	19.42706	737.01367	51.54997	51.69858	756.91724	252.95120	-26.04602

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	271.10669	785.80005	438.56348	341.58716	1.28549	0.41860	0.67716	0.42470
0.00107	10.74530	271.95557	788.10010	434.82275	336.42896	1.26664	0.41261	0.65971	0.41795
0.00214	21.38333	272.28467	788.60010	429.48584	329.54541	1.24857	0.40699	0.64197	0.41169
0.00319	31.88789	271.93921	786.39990	421.80322	320.05493	1.23083	0.40181	0.62324	0.40595
0.00422	42.23212	270.83960	781.89990	412.08350	308.37622	1.21310	0.39666	0.60352	0.40033
0.00524	52.40057	269.03882	775.30005	400.56641	294.72021	1.19568	0.39163	0.58310	0.39490
0.00624	62.37169	266.89624	766.60010	387.56958	279.10107	1.17857	0.38720	0.56226	0.39012
0.00721	72.12581	264.13232	756.00000	373.13672	261.73169	1.16177	0.38290	0.54092	0.38553
0.00817	81.65331	260.63086	743.60010	357.34717	242.71826	1.14525	0.37855	0.51903	0.38093
0.00909	90.94879	256.43433	729.39990	340.34351	222.06494	1.12893	0.37419	0.49663	0.37636
0.01000	100.00000	251.60667	713.39990	322.32886	199.77881	1.11279	0.36990	0.47387	0.37188

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.02000	444.21289	3.73667	1111.95996	9.82300	1393.69995	0.0	-9.72156	-2.94525	1.1701469
0.02000	451.67114	3.83710	1154.12036	9.82300	1435.69995	10.05018	-9.16822	-1.76330	1.1577034
0.02000	459.05469	3.93446	1191.37573	9.82300	1471.69995	10.11497	-8.65762	-0.60224	1.1499557
0.02000	466.34497	4.03097	1221.15967	9.82300	1498.69995	10.14844	-8.19002	0.53693	1.1494284
0.02000	473.52368	4.12712	1244.14917	9.82300	1517.69995	10.15033	-7.76183	1.66276	1.1550989
0.02000	480.57983	4.22228	1260.23267	9.82300	1528.69995	10.12900	-7.37156	2.77674	1.1666527
0.02000	487.49902	4.31645	1269.31299	9.82300	1531.69995	10.07798	-7.01744	3.88535	1.1841402
0.02000	494.26831	4.40943	1271.30640	9.82300	1526.69995	9.99754	-6.69622	4.99557	1.2077503
0.02000	500.88184	4.50136	1266.14795	9.82300	1513.69995	9.89982	-6.40640	6.10853	1.2379513
0.02000	507.33496	4.59247	1253.78735	9.82300	1492.69995	9.78374	-6.14510	7.22668	1.2754602
0.02000	513.62109	4.68285	1234.17822	9.82300	1463.69995	9.64796	-5.91014	8.35305	1.3212252

STATION NUMBER 6 DOWNSTREAM OF ROTOR 1

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.06100	635.54126	92.77013	92.80766	645.69971	146.31903	145.96194	295.99780	295.65186	-48.20180
0.06244	644.67187	94.37682	94.41795	655.19434	146.62611	146.37848	304.51880	303.63062	-41.41299
0.06385	652.37866	95.41292	95.44685	663.30347	146.75185	146.58655	313.26147	311.86475	-34.85094
0.06523	658.04980	96.00212	96.02583	669.30078	146.85260	146.74825	320.58081	318.82349	-28.37666
0.06658	661.96313	96.33865	96.35313	673.45337	147.02641	146.96626	325.84717	323.85498	-21.93408
0.06789	664.12817	96.25659	96.26369	675.88232	147.09549	147.06560	330.54028	328.57153	-15.69698
0.06917	664.59448	95.99332	95.99583	676.51904	147.25002	147.23903	333.15430	331.33325	-9.59624
0.07043	663.36328	95.42822	95.42854	675.42798	147.38005	147.37848	334.62842	333.12793	-3.68849
0.07165	660.42432	94.62958	94.62968	672.57007	147.55299	147.55257	334.42334	333.33226	1.99562
0.07284	655.75000	93.55740	93.55827	667.95093	147.73320	147.72670	332.96338	332.32178	7.41700
0.07400	649.32324	92.26857	92.27022	661.50635	147.96581	147.96718	329.78076	329.52222	12.53089

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	291.69604	-14.30506	528.19238	-437.69531	0.46574	0.45897	0.83109	0.46520
0.00144	11.08757	300.79297	-23.23932	548.36279	-456.62915	0.47236	0.46658	0.85061	0.47098
0.00285	21.93790	309.91113	-29.55074	566.33057	-472.72681	0.48018	0.47505	0.86810	0.47804
0.00423	32.53203	317.55811	-33.52127	581.45630	-486.25415	0.48717	0.48257	0.88361	0.48450
0.00558	42.89003	323.11133	-35.97481	594.08496	-498.05127	0.49224	0.48811	0.89746	0.48923
0.00689	53.00726	328.19629	-36.02242	604.34961	-507.22705	0.49771	0.49418	0.90999	0.49474
0.00817	62.88103	331.19409	-34.78520	612.29321	-514.89941	0.50129	0.49834	0.92130	0.49355
0.00943	72.51881	333.10742	-31.65518	617.94824	-520.46704	0.50444	0.50215	0.93154	0.50218
0.01065	81.91753	333.32517	-26.99225	621.27930	-524.28760	0.50638	0.50472	0.94073	0.50472
0.01184	91.07809	332.23877	-20.65967	622.37476	-526.22485	0.50776	0.50665	0.94910	0.50678
0.01300	100.00000	329.28369	-13.05364	621.26562	-526.67456	0.50788	0.50712	0.95679	0.50749

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.04000	423.39038	2.74648	1068.28491	3.16047	1104.85156	0.0	-9.38315	3.21201	0.8952293
0.04000	433.38989	2.73672	1101.11963	3.16097	1139.60522	10.13825	-7.83916	3.94964	0.8654479
0.04000	443.17627	2.72727	1129.23901	3.16435	1169.77368	10.15021	-6.41622	4.48965	0.8409843
0.04000	452.73291	2.71838	1150.17236	3.16708	1192.47070	10.12961	-5.10633	4.86488	0.8229864
0.04000	462.07666	2.71011	1164.74414	3.16705	1208.32935	10.11327	-3.88351	5.10866	0.8102180
0.04000	471.20483	2.70259	1172.88037	3.16886	1217.66260	10.07718	-2.73826	5.23928	0.8023650
0.04000	480.11426	2.69595	1174.63843	3.16817	1220.11499	10.02476	-1.65966	5.26742	0.7991946
0.04000	488.81201	2.69022	1169.99829	3.16788	1215.91357	9.96617	-0.63441	5.20234	0.8006599
0.04000	497.29541	2.68552	1159.00098	3.16651	1204.94653	9.89145	0.34303	5.05002	0.8068436
0.04000	505.56519	2.68189	1141.65747	3.16545	1187.33911	9.80463	1.27887	4.81637	0.8179936
0.04000	513.62109	2.67934	1118.05005	3.16327	1163.03760	9.70444	2.17934	4.50328	0.8344718

STATION NUMBER 7 DUMMY

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.05950	639.25537	93.55840	93.57407	645.69971	151.23042	151.12393	236.29485	235.83928	-22.07408
0.06125	648.29883	95.50461	95.51549	655.19434	151.33228	151.28430	246.99799	245.85896	-15.49180
0.06293	655.93042	96.67628	96.68066	663.30347	151.25475	151.23868	257.92529	256.17627	-9.33536
0.06454	661.52490	97.28270	97.28336	669.30078	151.18393	151.18179	267.25146	265.09546	-3.54143
0.06611	665.35254	97.59279	97.59300	673.45337	151.23250	151.23190	274.19971	271.79565	1.89639
0.06762	667.44531	97.40532	97.40756	675.88232	151.17409	151.16661	280.61523	278.27466	6.93054
0.06908	667.84326	97.02654	97.03233	676.51904	151.23212	151.21207	284.73877	282.60034	11.50113
0.07050	666.54272	96.30969	96.31905	675.42798	151.27016	151.23404	287.73145	285.98853	15.62484
0.07188	663.54199	95.34248	95.35440	672.57007	151.36414	151.31009	288.98755	287.73218	19.23833
0.07321	658.79736	94.07831	94.09059	667.95093	151.46768	151.39507	289.03418	288.30225	22.35487
0.07450	652.28979	92.58626	92.59604	661.50635	151.65253	151.56194	287.34838	287.05615	24.90839

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	234.80397	-14.66569	488.36475	-427.64478	0.36964	0.36731	0.76396	0.36893
0.00175	11.64097	245.37039	-23.69330	511.71191	-448.77881	0.38099	0.37848	0.78931	0.37924
0.00343	22.84738	256.00610	-29.98598	532.41187	-466.72925	0.39322	0.39029	0.81169	0.39055
0.00504	33.63196	265.07178	-33.87791	549.95386	-481.84424	0.40399	0.40070	0.83134	0.40073
0.00661	44.05684	271.78882	-36.23033	564.75244	-495.04785	0.41211	0.40849	0.84880	0.40850
0.00812	54.13957	278.18823	-36.16750	577.01709	-505.48193	0.42043	0.41680	0.86452	0.41693
0.00958	63.89584	282.35621	-34.83165	586.83301	-514.30542	0.42636	0.42280	0.87870	0.42315
0.01100	73.35091	285.56128	-31.62218	594.28296	-520.94434	0.43168	0.42842	0.89159	0.42906
0.01238	82.51311	287.08813	-26.90720	599.35645	-525.77417	0.43552	0.43266	0.90327	0.43363
0.01371	91.39339	287.43408	-20.55576	602.17651	-528.67627	0.43873	0.43630	0.91405	0.43762
0.01500	100.00000	285.97339	-12.96603	602.79541	-530.05762	0.44052	0.43841	0.92412	0.44007

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.05000	412.97925	2.89155	1081.57422	3.16047	1104.85156	0.0	-5.37064	13.04653	0.9309361
0.05000	425.08569	2.87664	1114.31299	3.16097	1139.60522	10.48958	-3.61266	12.72679	0.8989245
0.05000	436.74341	2.86267	1142.32373	3.16435	1169.77368	10.38415	-2.08839	12.30725	0.8726239
0.05000	447.96655	2.84973	1163.10718	3.16708	1192.47070	10.25956	-0.76544	11.82570	0.8531588
0.05000	458.81763	2.83790	1177.49976	3.16705	1208.32935	10.16448	0.39977	11.29992	0.8392298
0.05000	469.31445	2.82713	1185.42163	3.16886	1217.66260	10.06235	1.42712	10.74086	0.8304605
0.05000	479.47388	2.81753	1186.93066	3.16817	1220.11499	9.95300	2.33244	10.15308	0.8265864
0.05000	489.32227	2.80902	1182.00146	3.16788	1215.91357	9.84959	3.13189	9.53558	0.8275259
0.05000	498.86719	2.80166	1170.67163	3.16651	1204.94653	9.73486	3.83377	8.89146	0.8333451
0.05000	508.12061	2.79543	1152.94873	3.16545	1187.33911	9.61495	4.44717	8.22279	0.8442751
0.05000	517.09180	2.79030	1128.91211	3.16327	1163.03760	9.46744	4.97792	7.52739	0.8606698

STATION NUMBER 8 DUMMY

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.05950	641.16309	94.23730	94.25568	645.69971	94.25568	94.23730	198.48906	197.94652	18.40909
0.06152	650.14893	96.40335	96.44444	655.19434	96.44444	96.40335	211.51221	210.19267	23.80020
0.06343	657.72827	97.61328	97.67798	663.30347	97.67798	97.61328	224.54944	222.57002	29.00255
0.06524	663.26489	98.17238	98.25832	669.30078	98.25832	98.17238	235.77942	233.38507	33.80786
0.06698	667.02686	98.41148	98.51634	673.45337	98.51634	98.41148	244.47154	241.84180	38.10507
0.06864	669.04956	98.10347	98.21974	675.88232	98.21974	98.10347	252.78355	250.25957	42.22681
0.07023	669.36230	97.60672	97.72955	676.51904	97.72955	97.60672	258.84937	256.57129	45.82771
0.07176	667.96045	96.75826	96.87906	675.42798	96.87906	96.75826	264.01172	262.17725	49.14005
0.07323	664.83716	95.66258	95.77306	672.57007	95.77306	95.66258	267.66797	266.36182	52.02557
0.07464	659.95337	94.27573	94.36577	667.95093	94.36577	94.27573	270.41772	269.66504	54.58444
0.07600	653.27441	92.68106	92.74139	661.50635	92.74139	92.68106	271.72510	271.42773	56.67464

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	197.08362	-14.66569	198.48904	-14.66569	0.30958	0.30739	0.30958	0.30873
0.00202	12.22809	208.84087	-23.58919	211.51219	-23.58919	0.32533	0.32122	0.32533	0.32330
0.00393	23.81262	220.67232	-29.74953	224.54942	-29.74953	0.34140	0.33551	0.34140	0.33839
0.00574	34.80788	230.92340	-33.51631	235.77940	-33.51631	0.35548	0.34816	0.35548	0.35187
0.00748	45.31920	238.82097	-35.76137	244.47153	-35.76137	0.36651	0.35804	0.36651	0.36257
0.00914	55.38390	246.67134	-35.63249	252.78354	-35.63249	0.37782	0.36869	0.37782	0.37405
0.01073	65.03247	252.44533	-34.26424	258.84912	-34.26424	0.38671	0.37714	0.38671	0.38331
0.01226	74.30296	257.53076	-31.06883	264.01172	-31.06883	0.39525	0.38555	0.39525	0.39250
0.01373	83.21046	261.23145	-26.41061	267.66772	-26.41061	0.40261	0.39293	0.40261	0.40064
0.01514	91.77228	264.08276	-20.16121	270.41748	-20.16121	0.40975	0.40015	0.40975	0.40861
0.01650	100.00000	265.44482	-12.71013	271.72510	-12.71013	0.41594	0.40633	0.41594	0.41549

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.06000	0.0	2.96884	1088.43628	3.16047	1104.85156	0.0	5.33624	21.43896	0.9497915
0.06000	0.0	2.95048	1121.06836	3.16097	1139.60522	10.92114	6.50157	20.02423	0.9164432
0.06000	0.0	2.93359	1148.97949	3.16435	1169.77368	10.68206	7.48737	18.87151	0.8890622
0.06000	0.0	2.91788	1169.62842	3.16708	1192.47070	10.44116	8.32910	17.95149	0.8686899
0.06000	0.0	2.90316	1183.83569	3.16705	1208.32935	10.25687	9.06542	17.23193	0.8539357
0.06000	0.0	2.88929	1191.51367	3.16886	1217.66260	10.07359	9.71411	16.69876	0.8443798
0.06000	0.0	2.87615	1192.70459	3.16817	1220.11499	9.88830	10.28916	16.34293	0.8397003
0.06000	0.0	2.86357	1187.37549	3.16788	1215.91357	9.71451	10.80288	16.15608	0.8397784
0.06000	0.0	2.85144	1175.55469	3.16651	1204.94653	9.53123	11.26337	16.13551	0.8446297
0.06000	0.0	2.83966	1157.24731	3.16545	1187.33911	9.34361	11.67827	16.27576	0.8544478
0.06000	0.0	2.82809	1132.53101	3.16327	1163.03760	9.14749	12.05216	16.57713	0.8695364

STATION NUMBER 9 DUMMY

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.06150	641.65552	94.34081	94.56003	645.69971	94.56003	94.34081	187.46443	186.92670	57.37291
0.06364	650.66406	96.53033	96.87000	655.19434	96.87000	96.53033	200.48660	199.18579	62.12267
0.06567	658.27271	97.73950	98.15538	663.30347	98.15538	97.73950	213.37862	211.43488	67.06601
0.06758	663.84326	98.29477	98.75710	669.30078	98.75710	98.29477	224.27834	221.93219	71.66058
0.06942	667.64819	98.53694	99.03259	673.45337	99.03259	98.53694	232.44475	229.86935	75.65689
0.07117	669.71997	98.22702	98.72714	675.88232	98.72714	98.22702	240.15930	237.68782	79.85571
0.07285	670.09058	97.73425	98.22859	676.51904	98.22859	97.73425	245.44281	243.21002	83.53650
0.07447	668.75537	96.88634	97.35138	675.42798	97.35138	96.88634	249.68495	247.88376	87.18903
0.07603	665.71094	95.78787	96.20271	672.57007	96.20271	95.78787	252.22899	250.94316	90.53812
0.07754	660.92407	94.38757	94.72258	667.95093	94.72258	94.38757	253.67999	252.93657	93.75648
0.07900	654.35229	92.76505	92.99083	661.50635	92.99083	92.76505	253.47185	253.17674	96.56758

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	177.90430	-14.18876	187.46443	-14.18876	0.29216	0.27726	0.29216	0.29132
0.00214	12.25349	189.25050	-22.80113	200.48657	-22.80113	0.30813	0.29086	0.30813	0.30613
0.00417	23.81834	200.51646	-28.73540	213.37860	-28.73540	0.32415	0.30461	0.32415	0.32120
0.00608	34.76862	210.04440	-32.35542	224.27832	-32.35542	0.33785	0.31641	0.33785	0.33431
0.00792	45.22945	217.06209	-34.50560	232.44473	-34.50560	0.34815	0.32511	0.34815	0.34430
0.00967	55.24869	223.87175	-34.36551	240.15929	-34.36551	0.35860	0.33428	0.35860	0.35491
0.01135	64.86554	228.41357	-33.03108	245.44279	-33.03108	0.36628	0.34087	0.36628	0.36295
0.01297	74.12708	232.04402	-29.93690	249.68494	-29.93690	0.37336	0.34698	0.37336	0.37066
0.01453	83.05511	234.04128	-25.43597	252.22897	-25.43597	0.37889	0.35157	0.37889	0.37696
0.01604	91.67328	234.91833	-19.40689	253.67998	-19.40689	0.38383	0.35544	0.38383	0.38270
0.01750	100.00000	234.03667	-12.22746	253.47183	-12.22746	0.38736	0.35766	0.38736	0.38691

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.07000	0.0	2.98909	1090.21143	3.16047	1104 [illegible]156	0.0	17.87415	21.42619	0.9547159
0.07000	0.0	2.97135	1122.95312	3.16097	1139.60522	10.91414	18.17274	19.72159	0.9213769
0.07000	0.0	2.95540	1151.00000	3.16435	1169.77368	10.64385	18.49335	18.37459	0.8940990
0.07000	0.0	2.94093	1171.80640	3.16708	1192.47070	10.38536	18.83803	17.31827	0.8739250
0.07000	0.0	2.92773	1186.19092	3.16705	1208.32935	10.20052	19.21597	16.48776	0.8594527
0.07000	0.0	2.91566	1194.06543	3.16886	1217.66260	10.02492	19.63147	15.84735	0.8502637
0.07000	0.0	2.90465	1195.47632	3.16817	1220.11499	9.85780	20.08871	15.36631	0.8460529
0.07000	0.0	2.89460	1190.39526	3.16788	1215.91357	9.71129	20.59338	15.02022	0.8467245
0.07000	0.0	2.88549	1178.85498	3.16651	1204.94653	9.56402	21.14830	14.78644	0.8523238
0.07000	0.0	2.87733	1160.86523	3.[illegible]6545	1187.33911	9.42024	21.75705	14.64280	0.8630830
0.07000	0.0	2.87000	1136.50049	3.16327	1163.03760	9.27781	22.42189	14.57235	0.8793415

STATION NUMBER 10 DUMMY

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.06600	641.26294	93.86182	94.42331	645.69971	94.42331	93.86182	196.30923	195.86351	95.65250
0.06810	650.42407	95.94557	96.75508	655.19434	96.75508	95.94557	205.70514	204.59862	97.46567
0.07011	658.19409	97.18997	98.12134	663.30347	98.12134	97.18997	215.02652	213.33571	99.72090
0.07204	663.94067	97.84868	98.83031	669.30078	98.83031	97.84868	222.28198	220.19971	101.53561
0.07389	667.93604	98.22171	99.22658	673.45337	99.22658	98.22171	226.65279	224.32330	102.50674
0.07569	670.21191	98.05959	99.03369	675.88232	99.03369	98.05959	230.44771	228.17155	103.74971
0.07744	670.79810	97.70901	98.63884	676.51904	98.63884	97.70901	231.64041	229.54689	104.22554
0.07914	669.68872	96.98347	97.83124	675.42798	97.83124	96.98347	231.69469	229.97581	104.58864
0.08080	666.87720	95.97479	96.70956	672.57007	96.70956	95.97479	229.95030	228.70117	104.43840
0.08242	662.33252	94.61078	95.18813	667.95093	95.18813	94.61078	227.13922	226.40414	104.01982
0.08400	655.99756	92.96062	93.33922	661.50635	93.33922	92.96062	222.65030	222.35312	102.93074

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	170.91843	-13.22134	196.30923	-13.22134	0.30613	0.26653	0.30613	0.30543
0.00210	11.69090	179.89171	-21.30753	205.70514	-21.30753	0.31626	0.27658	0.31626	0.31456
0.00411	22.85443	188.59444	-26.91248	215.02652	-26.91248	0.32669	0.28653	0.32669	0.32412
0.00604	33.54063	195.39301	-30.35403	222.28198	-30.35403	0.33479	0.29429	0.33479	0.33166
0.00789	43.86029	199.53271	-32.41200	226.65277	-32.41200	0.33933	0.29873	0.33933	0.33585
0.00969	53.85257	203.21970	-32.30922	230.44769	-32.30922	0.34384	0.30322	0.34384	0.34045
0.01144	63.54987	204.52092	-31.07253	231.64040	-31.07253	0.34532	0.30489	0.34532	0.34220
0.01314	72.99591	204.81720	-28.17000	231.69467	-28.17000	0.34597	0.30584	0.34597	0.34341
0.01480	82.20766	203.46213	-23.93562	229.95029	-23.93562	0.34482	0.30510	0.34482	0.34294
0.01642	91.20393	201.09378	-18.25879	227.13921	-18.25879	0.34294	0.30361	0.34294	0.34183
0.01800	100.00000	197.09431	-11.49963	222.65027	-11.49963	0.33941	0.30045	0.33941	0.33895

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.08000	0.0	2.97292	1088.79541	3.16047	1104.85156	0.0	29.23303	11.24796	0.9507858
0.08000	0.0	2.96160	1122.07373	3.16097	1139.60522	10.45192	28.44891	9.84858	0.9190721
0.08000	0.0	2.95224	1150.70850	3.16435	1169.77368	10.28676	27.86803	8.61607	0.8933709
0.08000	0.0	2.94483	1172.17334	3.16708	1192.47070	10.12685	27.45856	7.52786	0.8748093
0.08000	0.0	2.93918	1187.28247	3.16705	1208.32935	10.03979	27.19110	6.54672	0.8620188
0.08000	0.0	2.93514	1195.93872	3.16886	1217.66260	9.96487	27.04565	5.64805	0.8546033
0.08000	0.0	2.93260	1198.17456	3.16817	1220.11499	9.89988	27.00375	4.80800	0.8522725
0.08000	0.0	2.93144	1193.94678	3.16788	1215.91357	9.86028	27.05084	4.00279	0.8549508
0.08000	0.0	2.93155	1183.26830	3.16651	1204.[illegible]4653	9.82206	27.17171	3.21459	0.8626981
0.08000	0.0	2.93280	1166.12451	3.16545	1187.33911	9.78854	27.35117	2.42904	0.8757554
0.08000	0.0	2.93508	1142.57178	3.16327	1163.03760	9.75901	27.57541	1.62871	0.8945016

STATION NUMBER 11 DUMMY

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.07200	640.30322	93.21098	93.72478	645.69971	93.72478	93.21098	216.37532	216.03563	109.60286
0.07383	649.77686	95.14621	95.89798	655.19434	95.89798	95.14621	219.12982	218.24654	106.91058
0.07562	657.83301	96.44029	97.31390	663.30347	97.31390	96.44029	222.44435	221.04060	105.20558
0.07738	663.83740	97.23380	98.15970	669.30078	98.15970	97.23380	224.39717	222.61113	103.54842
0.07912	668.05908	97.76234	98.71294	673.45337	98.71294	97.76234	224.12001	222.06638	101.48439
0.08083	670.53125	97.76590	98.68840	675.88232	98.68840	97.76590	223.90718	221.85362	100.09560
0.08251	671.28198	97.55870	98.43951	676.51904	98.43951	97.55870	221.69028	219.76395	98.31993
0.08417	670.30542	96.94698	97.74977	675.42798	97.74977	96.94698	218.97733	217.36971	96.81569
0.08580	667.59473	96.01550	96.71120	672.57007	96.71120	96.01550	215.06532	213.88109	95.17928
0.08742	663.12109	94.68614	95.23305	667.95093	95.23305	94.68614	210.71370	210.00934	93.68126
0.08900	656.82739	93.03050	93.38968	661.50635	93.38988	93.03050	205.29942	205.01231	91.94594

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	186.16821	-12.11956	216.37531	-12.11956	0.33793	0.29075	0.33793	0.33740
0.00183	10.74383	190.26738	-19.65521	219.12981	-19.65521	0.33724	0.29282	0.33724	0.33588
0.00362	21.30255	194.39836	-24.95081	222.44434	-24.95081	0.33815	0.29551	0.33815	0.33601
0.00538	31.65845	197.06200	-28.25548	224.39716	-28.25548	0.33803	0.29685	0.33803	0.33534
0.00712	41.86407	197.52060	-30.27046	224.12000	-30.27046	0.33548	0.29566	0.33548	0.33241
0.00883	51.91785	197.98962	-30.25549	223.90717	-30.25549	0.33393	0.29527	0.33393	0.33086
0.01051	61.81644	196.54356	-29.16141	221.69028	-29.16141	0.33025	0.29279	0.33025	0.32738
0.01217	71.58264	194.61835	-26.48540	218.97729	-26.48540	0.32668	0.29034	0.32668	0.32428
0.01380	81.20293	191.53593	-22.53815	215.06529	-22.53815	0.32215	0.28690	0.32215	0.32038
0.01542	90.67703	187.95674	-17.21448	210.71368	-17.21448	0.31776	0.28344	0.31776	0.31670
0.01700	100.00000	183.23750	-10.85359	205.29941	-10.85359	0.31256	0.27897	0.31256	0.31213

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.09000	0.0	2.93375	1085.33960	3.16047	1104.85156	0.0	30.48660	-6.00969	0.9412464
0.09000	0.0	2.93548	1119.70703	3.16097	1139.60522	9.73110	29.33147	-5.54109	0.9128917
0.09000	0.0	2.93777	1149.36816	3.16435	1169.77368	9.80120	28.42160	-5.11289	0.8900293
0.09000	0.0	2.94070	1171.78442	3.16708	1192.47070	9.84135	27.72018	-4.72335	0.8738720
0.09000	0.0	2.94410	1187.75098	3.16705	1208.32935	9.92043	27.19370	-4.34564	0.8631223
0.09000	0.0	2.94786	1197.15649	3.16886	1217.66260	9.98753	26.81932	-3.96451	0.8574337
0.09000	0.0	2.95187	1200.02222	3.16817	1220.11499	10.04429	26.57626	-3.56488	0.8565521
0.09000	0.0	2.95602	1196.29614	3.16788	1215.91357	10.10880	26.44870	-3.12593	0.8604261
0.09000	0.0	2.96023	1185.98901	3.16651	1204.94653	10.15630	26.42400	-2.62482	0.8691400
0.09000	0.0	2.96442	1169.08643	3.16545	1187.33911	10.19306	26.49254	-2.03319	0.8829550
0.09000	0.0	2.96843	1145.64160	3.16327	1163.03760	10.21592	26.64684	-1.31285	0.9022424

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B

STATION NUMBER 12   DUMMY

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.07715	640.53394	93.06224	93.33507	645.69971	93.33507	93.06224	211.72871	211.42639	83.82837
0.07881	650.20288	95.02032	95.45369	655.19434	95.45369	95.02032	210.39479	209.58768	82.08693
0.08049	658.41943	96.40083	96.94316	663.30347	96.94316	96.40083	210.26559	208.95486	81.29623
0.08217	664.55225	97.30396	97.91801	669.30078	97.91801	97.30396	209.29816	207.59987	80.59558
0.08385	668.88159	97.95200	98.62241	673.45337	98.62241	97.95200	206.43861	204.45360	79.55086
0.08554	671.44312	98.05325	98.74152	675.88232	98.74152	98.05325	204.05138	202.03909	79.10138
0.08723	672 27148	97.93584	98.62967	676.51904	98.62967	97.93584	199.77541	197.86224	78.23111
0.08892	671.36475	97.38029	98.04680	675.42798	98.04680	97.38029	195.15826	193.54149	77.55516
0.09061	668.71973	96.47231	97.08162	672.57607	97.08162	96.47231	189.32774	188.12106	76.66658
0.09231	664.31226	95.11021	95.61630	667.95093	95.61630	95.11021	183.02322	182.29575	75.82631
0.09400	658.09521	93.35840	93.71149	661.50635	93.71149	93.35840	175.42159	175.12033	74.63687

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	194.09770	-11.31054	211.72870	-11.31054	0.33055	0.30302	0.33055	0.33008
0.00166	9.86577	192.84378	-18.41124	210.39479	-18.41124	0.32358	0.29659	0.32358	0.32234
0.00334	19.81516	192.49170	-23.44096	210.26556	-23.44096	0.31935	0.29235	0.31935	0.31736
0.00502	29.77995	191.31664	-26.60849	209.29814	-26.60849	0.31495	0.28789	0.31495	0.31239
0.00670	39.78596	188.34258	-28.55922	206.43861	-28.55922	0.30863	0.28158	0.30863	0.30566
0.00839	49.81056	185.91063	-28.58606	204.05135	-28.58606	0.30390	0.27688	0.30390	0.30090
0.01008	59.83534	181.73981	-27.58162	199.77539	-27.58162	0.29716	0.27034	0.29716	0.29432
0.01177	69.87152	177.32315	-25.06873	195.15825	-25.06873	0.29069	0.26412	0.29069	0.28828
0.01346	79.90875	171.78989	-21.34137	189.32771	-21.34137	0.28312	0.25689	0.28312	0.28132
0.01516	89.94861	165.77727	-16.30212	183.02321	-16.30212	0.27551	0.24955	0.27551	0.27441
0.01685	100.00000	158.41864	-10.27627	175.42159	-10.27627	0.26656	0.24072	0.26656	0.26610

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.10000	0.0	2.94313	1086.16992	3.16047	1104.85156	0.0	23.35890	-14.96236	0.9435320
0.10000	0.0	2.95264	1121.26416	3.16097	1139.60522	8.99017	23.05777	-13.21025	0.9169543
0.10000	0.0	2.96130	1151.54468	3.16435	1169.77368	9.26041	22.89610	-11.73193	0.8954604
0.10000	0.0	2.96942	1174.47900	3.16708	1192.47070	9.47032	22.84413	-10.51452	0.8803821
0.10000	0.0	2.97710	1190.87451	3.16705	1208.32935	9.70632	22.89789	-9.51290	0.8705062
0.10000	0.0	2.98446	1200.63721	3.16886	1217.66260	9.92192	23.04881	-8.71407	0.8655637
0.10000	0.0	2.99163	1203.80347	3.16817	1220.11499	10.12008	23.28978	-8.10476	0.8653625
0.10000	0.0	2.99869	1200.33716	3.16788	1215.91357	10.32973	23.62294	-7.66839	0.8699081
0.10000	0.0	3.00572	1190.26025	3.16651	1204.94653	10.52880	24.05029	-7.40297	0.8793308
0.10000	0.0	3.01286	1173.57397	3.16545	1187.33911	10.73070	24.57928	-7.30547	0.8939494
0.10000	0.0	3.02009	1150.34131	3.16327	1163.03760	10.94151	25.22685	-7.37581	0.9141923

APPENDIX F: FLOW CONDITIONS, POWER TURBINE AND DIFFUSER

REGENERATIVE ENGINE STUDY PT

NO. OF STATIONS = 21 NO. OF STREAMLINES = 11 INLET WF/WA = 0.01920 EXIT OF INLET GUIDE VANE = STATION 8

1 SPOOL SPOOL STATIONS: 7 - 12

INPUT IS IN MKS UNITS DISTANCES ARE IN METERS, VELOCITIES ARE M./SEC.

Pressures in bar
Temperatures in K

INPUT TO AXIAL STATION 1 - STATOR

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0610	-0.0600	0.0740	-0.0600	0.4000	1.1711	44000.0

TOT PRESS	2.828	2.828	2.828	2.828	2.828	2.828	2.828	2.828	2.828	2.828	2.828
TOT TEMP	1062.50	1087.60	1108.10	1124.00	1135.20	1141.70	1143.60	1140.80	1133.40	1121.30	1104.60
VU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

1 bar = 14.5 psi
1 K = 1.8 $^{\circ}$R

INPUT TO AXIAL STATION 2 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0595	-0.0500	0.0745	-0.0500	0.4000	1.1711	44000.0

INPUT TO AXIAL STATION 3 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0595	-0.0400	0.0760	-0.0400	0.4000	1.1711	44000.0

INPUT TO AXIAL STATION 4 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0615	-0.0300	0.0790	-0.0300	0.3900	1.1711	44000.0

INPUT TO AXIAL STATION 5 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0660	-0.0200	0.0840	-0.0200	0.3800	1.1711	44000.0

INPUT TO AXIAL STATION 6 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0720	-0.0100	0.0890	-0.0100	0.3700	1.1711	44000.0

INPUT TO AXIAL STATION 7 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0771	0.0	0.0940	0.0	0.3600	1.1711	44000.0

Fixed Stator
Entrance

INPUT TO AXIAL STATION 8 - STATOR

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0806	0.0100	0.0980	0.0100	0.3500	1.1711	44000.0

TOT PRESS	2.791	2.791	2.791	2.791	2.791	2.791	2.791	2.791	2.791	2.791	2.791
VU	120.00	118.00	116.00	114.00	111.30	108.00	103.60	98.20	91.30	82.10	70.00

INPUT TO AXIAL STATION 9 - STATOR

Fixed Stator Exit
Variable Stator Entrance

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0824	0.0200	0.1005	0.0200	0.3500	1.1711	44000.0

TOT PRESS	2.754	2.754	2.754	2.754	2.754	2.754	2.754	2.754	2.754	2.754	2.754
VU	250.00	245.50	241.00	236.50	232.00	227.30	222.20	217.00	211.00	204.00	195.00

INPUT TO AXIAL STATION 10 - STATOR

Variable Stator Exit
Rotor Entrance

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0830	0.0300	0.1010	0.0300	0.9000	1.1711	44000.0

TOT PRESS	2.717	2.717	[illegible]	2.717	2.717	2.717	2.717	2.717	2.717	2.717	2.717
VU	594.20	595.50	593.90	589.70	583.10	574.40	563.90	551.60	538.10	523.40	507.70

INPUT TO AXIAL STATION 11 - ROTOR

Rotor Exit

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0806	0.0500	0.1030	0.0500	0.5000	1.1711	44000.0

DELTA H	54.28	55.56	56.61	57.42	57.99	58.32	58.42	58.28	57.90	57.28	56.43
ETA POLY	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000

INPUT TO AXIAL STATION 12 - DUMMY

Diffuser

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0784	0.0600	0.1030	0.0600	0.4000	1.1711	44000.0

INPUT TO AXIAL STATION 13 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0761	0.0700	0.1040	0.0700	0.3000	1.1711	44000.0

INPUT TO AXIAL STATION 14 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0716	0.0900	0.1060	0.0900	0.3000	1.1711	44000.0

INPUT TO AXIAL STATION 15 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0671	0.1100	0.1080	0.1100	0.2500	1.1711	0.0

INPUT TO AXIAL STATION 16 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0626	0.1300	0.1100	0.1300	0.2500	1.1711	0.0

INPUT TO AXIAL STATION 17 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0580	0.1500	0.1120	0.1500	0.2000	1.1711	0.0

INPUT TO AXIAL STATION 18 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0535	0.1700	0.1140	0.1700	0.2000	1.1711	0.0

INPUT TO AXIAL STATION 19 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0490	0.1900	0.1160	0.1900	0.2000	1.1711	0.0

INPUT TO AXIAL STATION 20 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0445	0.2100	0.1180	0.2100	0.2000	1.1711	0.0

INPUT TO AXIAL STATION 21 - DUMMY

HUB RADIUS	HUB STATION	TIP RADIUS	TIP STATION	MACH NO.	MASS FLOW	RPM
0.0355	0.2500	0.1220	0.2500	0.2000	1.1711	0.0

Diffuser

STREAMLINE DEFINITION: 0.0 0.100 0.200 0.300 0.400 0.500 0.600 0.700 0.800 0.900 1.000

AD-A095 144 AVCO LYCOMING DIV STRATFORD CT F/G 21/5

REGENERATIVE ENGINE ANALYSIS PROGRAM.(U)

JAN 81 P SCHWAAR, J DALE, J BANKS DAAK51-79-C-0056

UNCLASSIFIED LYC-80-73 USAAVRADCOM-TR-80-D-29 NL

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STATION NUMBER 7 DOWNSTREAM OF REMOTE

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.07715	630.17310	89.99997	89.99997	633.91602	155.27718	153.38838	178.10179	178.10179	70.21997
0.07882	637.30737	89.99997	89.99997	640.93091	155.89096	154.08681	176.45467	176.45467	68.70956
0.08050	643.09326	89.99997	89.99997	646.59302	156.53590	154.78786	174.64143	174.64143	67.64771
0.08219	647.56348	89.99997	89.99997	650.94995	157.21477	155.50099	172.57716	172.57716	66.91167
0.08388	650.72876	89.99997	89.99997	653.99951	157.92499	156.22887	170.23468	170.23468	66.41411
0.08557	652.60498	89.99997	89.99997	655.76147	158.66101	156.97107	167.60970	167.60970	66.05669
0.08727	653.23047	89.99997	89.99997	656.27539	159.41376	157.72304	164.73253	164.73253	65.76193
0.08896	652.58179	89.99997	89.99997	655.51807	160.17409	158.48129	161.62746	161.62746	65.43211
0.09065	650.67944	89.99997	89.99997	653.51074	160.93213	159.23961	158.33969	158.33969	65.00714
0.09233	647.48096	89.99997	89.99997	650.21240	161.67827	159.99252	154.91068	154.91068	64.42085
0.09400	642.99854	89.99997	89.99997	645.63062	162.40746	160.73860	151.34918	151.34918	63.61238

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	163.67468	0.0	397.60205	-355.48169	0.28262	0.25973	0.63094	0.28262
0.00167	9.90830	162.52765	0.0	403.77856	-363.18164	0.27688	0.25502	0.63357	0.27688
0.00335	19.87714	161.00751	0.0	409.98437	-370.92798	0.27156	0.25036	0.63752	0.27156
0.00504	29.88663	159.07767	0.0	416.17236	-378.70386	0.26650	0.24566	0.64267	0.26650
0.00673	39.92578	156.74504	0.0	422.33032	-386.50098	0.26161	0.24088	0.64901	0.26161
0.00842	49.98233	154.04388	0.0	428.45459	-394.31006	0.25683	0.23604	0.65653	0.25683
0.01012	60.04402	151.03699	0.0	434.55469	-402.12085	0.25218	0.23122	0.66524	0.25218
0.01181	70.09654	147.79062	0.0	440.63599	-409.92285	0.24767	0.22647	0.67522	0.24767
0.01350	80.12196	144.37979	0.0	446.70605	-417.70190	0.24335	0.22189	0.68652	0.24335
0.01518	90.09859	140.88033	0.0	452.76636	-425.44116	0.23925	0.21758	0.69927	0.23925
0.01685	100.00000	137.33185	0.0	458.80298	-433.12085	0.23538	0.21358	0.71354	0.23538

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.0	355.48169	2.68388	1049.19214	2.82800	1062.50000	0.0	23.22037	-14.43856	0.8907441
0.00000	363.18164	2.68969	1074.59302	2.82800	1087.60010	9.02931	22.91650	-12.16236	0.8715715
0.00000	370.92798	2.69493	1095.40332	2.82800	1108.10010	9.27952	22.78983	-10.43875	0.8566794
0.00000	378.70386	2.69981	1111.63452	2.82800	1124.00000	9.51463	22.81271	-9.11969	0.8456994
0.00000	386.50098	2.70442	1123.18994	2.82800	1135.19995	9.74069	22.96275	-8.10627	0.8384273
0.00000	394.31006	2.70881	1130.07007	2.82800	1141.69995	9.95680	23.21048	-7.30359	0.8346762
0.00000	402.12085	2.71299	1132.36987	2.82800	1143.60010	10.16103	23.52844	-6.65069	0.8342667
0.00000	409.92285	2.71695	1129.98486	2.82800	1140.80005	10.35079	23.88066	-6.06918	0.8372487
0.00000	417.70190	2.72067	1123.00806	2.82800	1133.39990	10.52092	24.23970	-5.50958	0.8436034
0.00000	425.44116	2.72411	1111.33423	2.82800	1121.30005	10.66663	24.57336	-4.98617	0.8535427
0.0	433.12085	2.72729	1095.06104	2.82800	1104.60010	10.77965	24.85367	-4.59597	0.8672369

STATION NUMBER 8 DOWNSTREAM OF NOZZLE 1

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.08055	629.06348	53.70889	52.83556	633.91602	147.77681	146.94926	202.74117	163.41351	40.56691
0.08225	636.26440	53.86723	52.88004	640.93091	149.14825	148.23285	200.11603	161.62433	42.59262
0.08398	642.13281	53.93396	52.85622	646.59302	150.52725	149.55315	197.03859	159.27400	43.78914
0.08572	646.68677	53.91508	52.76335	650.94995	151.90913	150.89864	193.55391	156.41968	44.38466
0.08749	649.93701	54.06241	52.85146	653.99951	153.27971	152.24965	189.63940	153.54288	44.65370
0.08926	651.90039	54.34937	53.08842	655.76147	154.63602	153.59789	185.29924	150.57161	44.70454
0.09103	652.61621	54.97754	53.67667	656.27539	155.95801	154.91988	180.52016	147.83289	44.69641
0.09280	652.06348	55.92250	54.58765	655.51807	157.25362	156.21942	175.25902	145.16365	44.67589
0.09456	650.26465	57.40794	56.04965	653.51074	158.50934	157.48065	169.49678	142.80571	44.75519
0.09630	647.17871	59.80414	58.45143	650.21240	159.70697	158.68730	163.23483	141.08578	44.98796
0.09800	642.81567	63.43224	62.15050	645.63062	160.85100	159.85291	156.51015	139.98366	45.18806

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	158.29814	120.00000	299.63184	-251.14795	0.32229	0.25164	0.47631	0.25977
0.00170	9.76129	155.91116	118.00000	306.99731	-261.00757	0.31452	0.24504	0.48250	0.25402
0.00343	19.65190	153.13626	116.00000	314.31177	-270.96826	0.30685	0.23848	0.48948	0.24804
0.00517	29.65474	149.99039	114.00000	321.61548	-281.01514	0.29930	0.23194	0.49733	0.24188
0.00694	39.74989	146.90630	111.30000	329.76025	-291.83301	0.29178	0.22603	0.50737	0.23624
0.00871	49.90425	143.78217	108.00000	338.61572	-303.29687	0.28424	0.22056	0.51943	0.23097
0.01048	60.07889	140.91412	103.60001	348.75732	-315.87524	0.27661	0.21592	0.53440	0.22652
0.01226	70.22934	138.11787	98.20000	359.99731	-329.43237	0.26878	0.21182	0.55209	0.22262
0.01401	80.31239	135.61136	91.30000	372.86523	-344.43457	0.26066	0.20855	0.57341	0.21961
0.01575	90.26392	133.72090	82.10001	388.17700	-361.62988	0.25223	0.20662	0.59980	0.21800
0.01745	100.00000	132.48947	70.00000	406.41992	-381.55176	0.24348	0.20611	0.63225	0.21777

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.01000	371.14795	2.60776	1045.24878	2.79100	1062.50000	0.0	14.37380	-13.80823	0.8687471
0.01000	379.00757	2.61639	1070.86572	2.79100	1087.60010	8.90021	15.27954	-13.59480	0.8507696
0.01000	386.96826	2.62466	1091.93311	2.79100	1108.10010	9.20833	15.95783	-13.45024	0.8369922
0.01000	395.01514	2.63258	1108.44165	2.79100	1124.00000	9.50712	16.48436	-13.39176	0.8270161
0.01000	403.13306	2.64026	1120.29248	2.79100	1135.19995	9.79336	16.90720	-13.43919	0.8206549
0.01000	411.29687	2.64775	1127.48291	2.79100	1141.69995	10.05163	17.27144	-13.61552	0.8177341
0.01000	419.47534	2.65513	1130.11182	2.79100	1143.60010	10.27414	17.59845	-13.95500	0.8181049
0.01000	427.63257	2.66248	1128.08154	2.79100	1140.80005	10.45085	17.92442	-14.48808	0.8218479
0.01000	435.73462	2.66988	1121.49048	2.79100	1133.39990	10.58142	18.26419	-15.24677	0.8289754
0.01000	443.72998	2.67733	1110.23340	2.79100	1121.30005	10.63774	18.59457	-16.20714	0.8397178
0.01000	451.55176	2.68481	1094.39893	2.79100	1104.60010	10.59517	18.83292	-17.33411	0.8542472

STATION NUMBER 9 DOWNSTREAM OF NOZZLE 2

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.08240	623.85132	30.86328	30.67960	633.91602	131.16257	130.95558	291.24170	149.40445	17.97859
0.08427	631.19800	31.58290	31.39392	640.93091	133.62892	133.41707	288.18506	150.93169	18.29976
0.08613	637.23950	32.09581	31.89401	646.59302	136.10112	135.87671	284.47974	151.15451	18.85118
0.08796	641.96826	32.44269	32.22270	650.94995	138.55775	138.31607	280.23706	150.33484	19.51369
0.08979	645.37964	32.64510	32.40405	653.99951	140.98727	140.72696	275.52539	148.62769	20.15494
0.09162	647.49634	32.78876	32.52744	655.76147	143.35506	143.07922	270.37866	146.42177	20.64366
0.09343	648.35815	32.96895	32.69247	656.27539	145.60733	145.32396	264.84985	144.12724	20.86685
0.09524	647.94092	33.05711	32.77702	655.51807	147.79659	147.51906	258.91064	141.22920	20.56485
0.09703	646.27002	33.33975	33.07068	653.51074	149.80254	149.54660	252.56570	138.81079	19.77182
0.09879	643.30640	33.91341	33.66943	650.21240	151.58817	151.36670	245.81818	137.15166	18.53102
0.10050	639.04834	35.24387	35.03473	645.63062	152.97830	152.79803	238.76483	137.78114	17.09299

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	148.31877	250.00000	197.82959	-129.67212	0.46684	0.23775	0.31711	0.23949
0.00187	10.35220	149.81819	245.50000	207.78899	-142.81421	0.45657	0.23736	0.32920	0.23912
0.00373	20.58168	149.97440	241.00000	217.11217	-155.85254	0.44643	0.23535	0.34071	0.23720
0.00556	30.73766	149.06300	236.50000	226.06046	-168.82764	0.43653	0.23220	0.35214	0.23418
0.00739	40.84782	147.25478	232.00000	234.79266	-181.76196	0.42692	0.22817	0.36381	0.23029
0.00922	50.92728	144.95921	227.30000	243.74791	-194.86845	0.41758	0.22388	0.37645	0.22614
0.01103	60.95825	142.60869	222.20000	253.32780	-208.33223	0.40849	0.21995	0.39072	0.22230
0.01284	70.93460	139.72392	217.00000	262.98755	-221.84863	0.39959	0.21564	0.40588	0.21797
0.01463	80.82675	137.39545	211.00000	273.87646	-236.09302	0.39081	0.21260	0.4[illegible]78	0.21479
0.01639	90.56384	135.89400	204.00000	286.20874	-251.20679	0.38212	0.21124	0.44490	0.21320
0.01810	100.00000	136.71677	195.00000	301.40601	-268.07080	0.37363	0.21394	0.47165	0.21560

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.02000	379.67212	2.39092	1026.83789	2.75400	1062.50000	0.0	6.91144	-12.46886	0.8107896
0.02000	388.31421	2.40593	1052.84204	2.75400	1087.60010	9.43373	6.96398	-13.94544	0.7957273
0.02000	396.85254	2.42038	1074.35034	2.75400	1108.10010	9.53006	7.16428	-14.61982	0.7844803
0.02000	405.32764	2.43417	1091.33911	2.75400	1124.00000	9.66701	7.45813	-14.76321	0.7766703
0.02000	413.76196	2.44728	1103.68945	2.75400	1135.19995	9.82579	7.79372	-14.57178	0.7721162
0.02000	422.16846	2.45977	1111.39087	2.75400	1141.69995	9.99740	8.10501	-14.25195	0.7706767
0.02000	430.53223	2.47164	1114.52979	2.75400	1143.60010	10.14898	8.32459	-13.94399	0.7722158
0.02000	438.84863	2.48304	1113.00903	2.75400	1140.80005	10.29133	8.37280	-13.84370	0.7768359
0.02000	447.09302	2.49404	1106.92529	2.75400	1133.39990	10.39879	8.18890	-14.05764	0.7845663
0.02000	455.20679	2.50468	1096.17383	2.75400	1121.30005	10.42490	7.76518	-14.55134	0.7956435
0.02000	463.07080	2.51486	1080.83154	2.75400	1104.60010	10.28199	7.12642	-15.10348	0.8102162

STATION NUMBER 10 DOWNSTREAM OF NOZZLE 3

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.08300	581.53540	23.30493	23.30458	633.91602	50.39795	50.39841	646.98608	255.96362	-1.47867
0.08478	590.24683	22.07143	22.07114	640.93091	49.68767	49.68808	642.59155	241.46170	-1.28296
0.08662	597.66406	21.06177	21.06177	646.59302	49.58171	49.58174	636.41675	228.71188	0.22152
0.08850	603.79126	20.28699	20.28589	650.94995	50.15552	50.15718	628.69971	217.98451	2.37260
0.09041	608.61084	19.77232	19.76761	653.99951	51.53131	51.53851	619.63086	209.61095	4.76657
0.09232	612.11792	19.51790	19.50705	655.76147	53.78525	53.80168	609.41895	203.60777	7.06155
0.09420	614.32690	19.54482	19.52621	656.27539	57.00710	57.03404	598.37842	200.18398	9.08130
0.09603	615.19019	19.92726	19.90149	655.51807	61.34886	61.38268	586.72998	199.97343	10.59150
0.09778	614.71362	20.55463	20.52458	653.51074	66.51172	66.54515	574.68579	201.77246	11.39103
0.09944	612.85547	21.43922	21.40857	650.21240	72.37256	72.39857	562.30835	205.53178	11.52297
0.10100	609.62207	22.51988	22.49075	645.63062	78.61530	78.63126	549.60962	210.50282	11.28009

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	255.95937	594.19995	332.20630	211.76318	1.11255	0.44014	0.57126	0.44015
0.00178	9.87905	241.45830	595.50000	316.65674	204.86060	1.08868	0.40908	0.53648	0.40909
0.00362	20.10175	228.71178	593.89990	300.41016	194.77466	1.06484	0.38268	0.50264	0.38268
0.00550	30.56430	217.97160	589.69995	283.90601	181.89380	1.04125	0.36100	0.47021	0.36103
0.00741	41.16371	209.55675	583.10010	267.69312	166.50195	1.01811	0.34432	0.43984	0.34441
0.00932	51.76685	203.48528	574.39990	252.30898	149.00903	0.99559	0.33243	0.41219	0.33263
0.01120	62.23401	199.97787	563.89990	238.59990	129.83179	0.97404	0.32562	0.38839	0.32586
0.01303	72.39896	199.69275	551.60010	227.80199	109.10718	0.95374	0.32460	0.37030	0.32506
0.01478	82.12834	201.45065	538.10010	219.94560	87.54395	0.93488	0.32771	0.35780	0.32824
0.01644	91.34523	205.20851	523.39990	215.62666	65.20386	0.91752	0.33484	0.35184	0.33537
0.01800	100.00000	210.20038	507.69995	214.71576	42.32520	0.90156	0.34480	0.35221	0.34530

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.03000	382.43677	1.28279	884.02148	2.71700	1062.50000	0.0	-0.33099	-12.54411	0.5052887
0.03000	390.63940	1.32203	912.45215	2.71700	1087.60010	9.00785	-0.30443	-11.22702	0.5045161
0.03000	399.12524	1.36158	937.04102	2.71700	1108.10010	9.52254	0.05549	-10.14881	0.5059751
0.03000	407.80615	1.40106	957.64087	2.71700	1124.00000	9.95772	0.62363	-9.26733	0.5094485
0.03000	416.59814	1.44009	974.02661	2.71700	1135.19995	10.30618	1.30302	-8.53069	0.5148310
0.03000	425.39087	1.47825	986.05054	2.71700	1141.69995	10.52968	1.98754	-7.86389	0.5220295
0.03000	434.06812	1.51497	993.66553	2.71700	1143.60010	10.61055	2.60010	-7.17281	0.5308961
0.03000	442.49292	1.54964	996.65088	2.71700	1140.80005	10.50932	3.03607	-6.35405	0.5414174
0.03000	450.55615	1.58185	995.00244	2.71700	1133.39990	10.24848	3.23635	-5.31533	0.5535865
0.03000	458.19604	1.61148	988.58887	2.71700	1121.30005	9.87933	3.21392	-4.02327	0.5676153
0.03000	465.37476	1.63860	977.48486	2.71700	1104.60010	9.42829	3.07175	-2.45563	0.5837256

STATION NUMBER 11 DOWNSTREAM OF ROTOR 1

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.08060	569.20679	90.00270	90.00276	576.69897	148.33694	147.79648	233.90814	233.90814	-47.45406
0.08308	575.76807	89.99336	89.99326	583.31885	148.57819	148.23766	236.97789	236.97789	-38.42163
0.08549	581.08154	89.97446	89.97423	588.68652	148.93761	148.72729	239.18987	239.18983	-30.67128
0.08785	585.19141	89.94997	89.94969	592.81128	149.38480	149.25853	240.62764	240.62755	-24.05975
0.09016	588.08716	89.93063	89.93047	595.69775	149.89433	149.82161	241.41707	241.41690	-18.43205
0.09242	589.77588	89.91243	89.91228	597.36621	150.44556	150.40675	241.64731	241.64702	-13.56630
0.09463	590.29248	89.90331	89.90326	597.85327	151.03197	151.01421	241.33949	241.33914	-9.23610
0.09680	589.61646	89.95473	89.95473	597.13574	151.66624	151.66072	240.44543	240.44534	-5.16782
0.09891	587.77271	89.98297	89.98297	595.23462	152.33141	152.33113	238.92436	238.92435	-1.17874
0.10098	584.72998	90.00052	90.00052	592.11328	153.04037	153.03873	236.67610	236.67610	2.77741
0.10300	580.51050	89.98871	89.98871	587.77417	153.80223	153.79317	233.57492	233.57491	6.61252

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	229.04395	-0.01077	438.91113	-371.38916	0.41094	0.40239	0.77109	0.41094
0.00248	11.06041	233.84247	0.02727	450.18896	-382.76831	0.41159	0.40614	0.78189	0.41159
0.00489	21.84398	237.21519	0.10646	460.76733	-393.82080	0.41163	0.40823	0.79295	0.41163
0.00725	32.38297	239.42169	0.20998	470.74316	-404.59570	0.41119	0.40913	0.80443	0.41119
0.00956	42.69357	240.71223	0.29200	480.24658	-415.15625	0.41051	0.40931	0.81662	0.41051
0.01182	52.78333	241.26590	0.36910	489.32324	-425.49268	0.40973	0.40908	0.82968	0.40973
0.01403	62.65511	241.16234	0.40706	498.02466	-435.64209	0.40885	0.40855	0.84369	0.40885
0.01620	72.31032	240.38980	0.18974	506.53003	-445.82373	0.40780	0.40771	0.85908	0.40780
0.01831	81.75064	238.92143	0.07076	514.52271	-455.68506	0.40649	0.40649	0.87538	0.40649
0.02038	90.97882	236.65981	-0.00188	522.01733	-465.28125	0.40476	0.40473	0.89275	0.40476
0.02240	100.00000	233.48129	0.04570	528.91333	-474.54419	0.40236	0.40220	0.91112	0.40236

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.05000	371.37842	0.97546	844.50757	1.09023	868.39868	0.0	-11.70512	-4.97487	0.4022095
0.05000	382.79565	0.97573	865.40894	1.09073	889.81860	9.86026	-9.33065	-4.24456	0.3926024
0.05000	393.92725	0.97618	882.54883	1.09112	907.32593	9.90067	-7.36732	-3.56245	0.3851565
0.05000	404.80591	0.97677	895.90454	1.09142	920.91211	9.95058	-5.73845	-2.92706	0.3796446
0.05000	415.44824	0.97737	905.36206	1.09162	930.48608	9.99705	-4.37877	-2.33530	0.3759069
0.05000	425.86182	0.97792	910.90308	1.09174	936.04712	10.03400	-3.21833	-1.80047	0.3738320
0.05000	436.04932	0.97842	912.60181	1.09177	937.67334	10.05774	-2.19326	-1.35275	0.3733273
0.05000	446.01367	0.97890	910.37964	1.09172	935.27734	10.06697	-1.23153	-1.03345	0.3744218
0.05000	455.75586	0.97941	904.33252	1.09158	928.94653	10.06317	-0.28267	-0.88405	0.3771219
0.05000	465.27954	0.98005	894.40234	1.09137	918.60449	10.04686	0.67238	-0.93614	0.3815563
0.05000	474.59009	0.98090	880.69800	1.09106	904.33716	10.02268	1.62226	-1.23539	0.3878308

STATION NUMBER 12 DUMMY

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.07835	571.12109	90.00319	90.00325	576.69897	151.38791	150.76056	202.09422	202.09422	-45.37480
0.08122	577.56348	89.99220	89.99210	583.31885	151.45271	151.03372	207.14755	207.14755	-38.24303
0.08398	582.76367	89.97057	89.97025	588.68652	151.63292	151.36566	211.22174	211.22171	-31.33038
0.08664	586.76831	89.94308	89.94270	592.81128	151.89612	151.73613	214.51747	214.51736	-24.76344
0.08921	589.55322	89.92206	89.92178	595.69775	152.22507	152.13808	217.13843	217.13823	-18.59167
0.09170	591.12964	89.90271	89.90254	597.36621	152.59505	152.55466	219.24223	219.24191	-12.85863
0.09411	591.53076	89.89375	89.89369	597.85327	152.99791	152.98421	220.87732	220.87694	-7.58532
0.09644	590.73145	89.95079	89.95079	597.13574	153.43777	153.43597	222.07347	222.07338	-2.81017
0.09870	588.75171	89.98172	89.98172	595.23462	153.89070	153.89021	222.84883	222.84882	1.43718
0.10088	585.55371	90.00052	90.00052	592.11328	154.35724	154.35127	223.20181	223.20181	5.13993
0.10300	581.15112	89.98822	89.98822	587.77417	154.83502	154.81978	223.10324	223.10323	8.28569

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	196.93451	-0.01108	413.73779	-361.02197	0.35386	0.34482	0.72443	0.35386
0.00287	11.65898	203.58678	0.02789	427.73071	-374.22388	0.35866	0.35249	0.74058	0.35866
0.00563	22.85188	208.88518	0.10838	440.76318	-386.85620	0.36245	0.35844	0.75633	0.36245
0.00829	33.64018	213.08325	0.21292	453.01489	-399.00488	0.36559	0.36315	0.77205	0.36559
0.01086	44.06470	216.34084	0.29512	464.62378	-410.76294	0.36831	0.36696	0.78809	0.36831
0.01335	54.15260	218.86450	0.37203	475.68042	-422.14307	0.37089	0.37025	0.80470	0.37089
0.01576	63.92169	220.74664	0.40935	486.26050	-433.20068	0.37340	0.37318	0.82204	0.37340
0.01809	73.38435	222.05559	0.19044	496.58911	-444.16675	0.37593	0.37590	0.84063	0.37593
0.02035	82.54869	222.84419	0.07092	506.36841	-454.69482	0.37851	0.37850	0.86007	0.37851
0.02254	91.42000	223.14261	-0.00188	515.65405	-464.84424	0.38118	0.38108	0.88063	0.38118
0.02465	100.00000	222.94931	0.04570	524.37305	-474.54419	0.38390	0.38363	0.90230	0.38390

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.06000	361.01099	1.00366	850.57617	1.09023	868.39868	0.0	-12.97484	-0.10418	0.4108825
0.06000	374.25195	1.00200	871.17896	1.09073	889.81860	10.25884	-10.63883	-0.17172	0.4005013
0.06000	386.96460	1.00067	888.01538	1.09112	907.32593	10.19651	-8.53013	0.03795	0.3923873
0.06000	399.21802	0.99953	901.04736	1.09142	920.91211	10.15034	-6.62889	0.46254	0.3862715
0.06000	411.05811	0.99846	910.17114	1.09162	930.48608	10.10876	-4.91176	1.05604	0.3819909
0.06000	422.51514	0.99737	915.35889	1.09174	936.04712	10.06334	-3.36235	1.76690	0.3794096
0.06000	433.61011	0.99620	916.68164	1.09177	937.67334	10.00917	-1.96803	2.55005	0.3784178
0.06000	444.35718	0.99491	914.04687	1.09172	935.27734	9.94233	-0.72505	3.34726	0.3790170
0.06000	454.76587	0.99348	907.54004	1.09158	928.94653	9.86109	0.36951	4.12736	0.3811866
0.06000	464.84253	0.99192	897.08521	1.09137	918.60449	9.76325	1.31953	4.89302	0.3850247
0.06000	474.59009	0.99021	882.77490	1.09106	904.33716	9.64633	2.12836	5.69336	0.3905894

STATION NUMBER 21 DUMMY

RADIUS M	A STATIC M/S	ALPHA BAR DEG	ALPHA DEG	A TOTAL M/S	BETA DEG	BETA BAR DEG	V M/S	VM M/S	VR M/S
0.03549	576.21021	90.02341	90.02396	576.69897	90.02396	90.02341	60.03233	60.03232	-13.20479
0.05181	582.78809	89.96019	89.95992	583.31885	89.95992	89.96019	63.04822	63.04820	-7.62933
0.06379	588.12207	89.87500	89.87468	588.68652	89.87468	89.87500	65.42917	65.42900	-4.48126
0.07370	592.22266	89.78648	89.78638	592.81128	89.78638	89.78648	67.19534	67.19489	-2.17325
0.08234	595.09351	89.73184	89.73184	595.69775	89.73184	89.73184	68.33368	68.33292	-0.30354
0.09012	596.75317	89.68556	89.68550	597.36621	89.68550	89.68556	68.99660	68.99556	1.27431
0.09727	597.23804	89.67184	89.67157	597.85327	89.67157	89.67184	69.15771	69.15656	2.63233
0.10394	596.52563	89.85277	89.85254	597.13574	89.85254	89.85277	68.79783	68.79765	3.80817
0.11023	594.63696	89.94643	89.94626	595.23462	89.94626	89.94643	67.93549	67.93546	4.82732
0.11623	591.53345	90.00145	90.00145	592.11328	90.00145	90.00145	66.64177	66.64177	5.70658
0.12200	587.21997	89.96582	89.96565	587.77417	89.96565	89.96582	64.76723	64.76720	6.44470

S-VALUE M	% SPAN	VX M/S	VU M/S	W M/S	WU M/S	MV	MVX	MW	MVM
0.0	0.0	58.56204	-0.02446	60.03232	-0.02446	0.10418	0.10163	0.10418	0.10418
0.01632	18.86320	62.58488	0.04373	63.04822	0.04373	0.10818	0.10739	0.10818	0.10818
0.02830	32.71503	65.27536	0.14270	65.42914	0.14270	0.11125	0.11099	0.11125	0.11125
0.03821	44.16351	67.15973	0.25035	67.19534	0.25035	0.11346	0.11340	0.11346	0.11346
0.04685	54.15456	68.33223	0.31978	68.33365	0.31978	0.11483	0.11483	0.11483	0.11483
0.05463	63.14893	68.98378	0.37856	68.99658	0.37856	0.11562	0.11560	0.11562	0.11562
0.06178	71.41179	69.10643	0.39605	69.15768	0.39605	0.11580	0.11571	0.11580	0.11579
0.06845	79.11940	68.69217	0.17671	68.79782	0.17671	0.11533	0.11515	0.11533	0.11533
0.07474	86.39702	67.76373	0.06349	67.93546	0.06349	0.11425	0.11396	0.11425	0.11425
0.08074	93.33157	66.39699	-0.00163	66.64177	-0.00163	0.11266	0.11225	0.11266	0.11266
0.08651	100.00000	64.44576	0.03858	64.76720	0.03858	0.11029	0.10975	0.11029	0.11029

X-VALUE M	U M/S	STAT PRESS BARS	STAT TEMP K	TOT PRESS BARS	TOT TEMP K	% AREA	EPS DEG	DEPS/DM RAD/M	RHO KG/CU.M
0.25000	0.0	1.08237	866.82861	1.09023	868.39868	0.0	-12.70676	0.0	0.4347991
0.25000	0.0	1.08227	888.09497	1.09073	889.81860	10.45610	-6.95027	0.0	0.4243471
0.25000	0.0	1.08218	905.47607	1.09112	907.32593	10.16744	-3.92729	0.0	0.4161677
0.25000	0.0	1.08213	918.96631	1.09142	920.91211	9.99446	-1.85341	0.0	0.4100403
0.25000	0.0	1.08211	928.47778	1.09162	930.48608	9.89868	-0.25451	0.0	0.4058304
0.25000	0.0	1.08210	934.00195	1.09174	936.04712	9.84927	1.05828	0.0	0.4034278
0.25000	0.0	1.08211	935.61914	1.09177	937.67334	9.83152	2.18140	0.0	0.4027337
0.25000	0.0	1.08213	933.24365	1.09172	935.27734	9.84703	3.17313	0.0	0.4037673
0.25000	0.0	1.08217	926.96094	1.09158	928.94653	9.89671	4.07472	0.0	0.4065176
0.25000	0.0	1.08221	916.68994	1.09137	918.60449	9.97158	4.91230	0.0	0.4110889
0.25000	0.0	1.08227	902.52344	1.09106	904.33716	10.08720	5.71070	0.0	0.4175636

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